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ADVERTISING RATES GIVEN ON APPLICATION.

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NOTICE.—After June 1, 1903, the offices of the ELECTROCHEMICAL INDUSTRY will be located at 114 Liberty street, N. Y.

CONTENTS.

Editorial	341
Union Engineering Building	344
Niagara Falls Meeting of the American Institute of Electrical Engineers	344
Fall Meeting of the American Electrochemical Society	344
The Composition of Electroplating Solutions. By N. S. Keith	345
Modern Electrolytic Copper Refining. By Titus Ulke	346
Anodes for Electroplating. By C. F. Burgess and Carl Hambuechen	347
Nickel Cathodes. By David H. Browne	348
Prof. F. Haber on Electrochemistry in the United States—I	349
Electrochemical Analysis. By Ivar Juel Moltkehanzen	351
Conditions of Progress in Electrochemistry (concluded)	352
Analysis of Current Electrochemical Patents. By George P. Scholl	353
Current Notes	356
American Electrochemical Society	356
Synopsis of Articles in Other Journals. By Carl Hering	357
Book Reviews	362
Correspondence: Cost of Electrical Steel Process. By Louis Simpson	363
Electric Automobile Charging Outfits	363
The Electrolyte for Storage Batteries	365
Chemical Apparatus made of Quartz	365
Carbon Determination Apparatus	366
Alternating Current Long Scale Voltmeter and Ammeter	366
Industrial Notes	367
Personal	367
Digest of U. S. Patents, prior to July, 1902. By Byrnes & Townsend	368

ANNOUNCEMENT.

On June 1st the offices of ELECTROCHEMICAL INDUSTRY will be transferred to New York City. There will be no change either in the business or the editorial staff. As the metropolis and center of the industrial activity of the United States, New York has become the seat of nearly all the leading technical journals of this country, as well as of most of the national engineering societies. A technical newspaper, which endeavors to be a newspaper in the best sense of the word, can only in the highest degree discharge its functions by keeping constantly in touch with the men alongside of the facts—those who make the history of the industries of this country. It is with regret that the members of the staff of ELECTROCHEMICAL INDUSTRY leave old, beautiful Philadelphia, but this regret is accompanied by the recognition of the fact, which became more evident from day to day, that at their new seat of activity they will have better opportunities than heretofore for manifesting their devotion to the cause in which this journal is enlisted.

In the nine months of its life, ELECTROCHEMICAL INDUSTRY has won many friends. While we have refrained so far from speaking for ourselves, and have preferred to let ELECTROCHEMICAL INDUSTRY stand on its own merits, we may here thank our friends for the support they have given us. ELECTROCHEMICAL INDUSTRY is read wherever there is chemical, metallurgical or electrical activity. Our friends are found in the laboratories and workshops of the manufacturing concerns, not only in this country, but all over the world. We doubt whether any technical journal has ever acquired in such a short time a subscription list so fully representative of an art and industry. To all our friends we send our greetings and renew the promises made when this journal was started; and we trust that in its new home ELECTROCHEMICAL INDUSTRY will be found even more ardent than heretofore in its zeal to be the worthy journalistic exponent of the young, splendid and swiftly advancing industry whose name it bears.

ELECTROPLATING.

In this issue we publish two interesting articles on electroplating, especially nickelplating, which somewhat supplement each other, the one by Messrs. C. F. Burgess and Carl Hambuechen on the most suitable form of the anode, the other by Mr. D. H. Browne on the well-known phenomenon of curling up of electrolytically-deposited nickel sheets. At first sight electroplating appears to be the most simple problem of electrochemistry. We have an electrolyte, the cation of which is the metal to be deposited, and an anode of the same metal, so that the same quantity of metal which is deposited on the cathode goes into solution at the anode and the conditions should be unchanged. It will, however, be seen that under no circumstances is the matter so simple. Even if the process

goes on in the first moment in the way just described, the conditions are at once changed on account of concentration changes developing at the anode and cathode, the layer of electrolyte on the cathode surface becoming more dilute and the layer on the anode surface more concentrated. We have, therefore, in the second moment an electrochemical system different from the original one.

The principal problem in electroplating is, however, as Mr. Browne puts it, to maintain initially good conditions to the end. Any influence which tends to change the conditions must be counteracted. This is the reason why stirring the electrolyte or revolving the electrode is of such importance, because the concentration of the electrolyte is thus made uniform throughout the cell and new ions are supplied to the points where they are wanted and where their number has decreased, in the surface layer next to the cathode. The account of the extended experiments of Mr. Browne concerning the best conditions for electrolytically depositing nickel sheets of almost any desired thickness will be read with great interest.

The phenomenon of curling up of electrolytically-deposited nickel sheets is undoubtedly due to a difference in surface tension on both sides of the sheet. The tendency to curl increases with the current density used, but the curling is always anodeward and around the longer axis of the rectangular cathode, irrespective of the way in which the cathode hung in the bath. This brings up the question whether the variation of the current density over the surface of the cathode has here not an important influence, analogous to that shown by Messrs. Burgess and Hambuechen to exist in the case of the anode.

Theoretically the quality of the deposit obtained should depend upon nothing but the conditions which exist in the surface layer of electrolyte next to the cathode. If the metal of the cathode alloys well with the metal to be deposited or is otherwise a suitable material for yielding a firmly adherent deposit, and if the layer of electrolyte next to the cathode contains a sufficient number of cations to be deposited with the current density employed, then the deposit should be good. Theoretically, therefore, the quality of the deposit does not depend on the anode, as there can be no action into the distance. But it can easily be seen that it would be absolutely wrong to believe that the form of the anode does not matter.

As was said before, the main problem in electroplating is to maintain initially good conditions. For this purpose it is necessary that the same amount of metal is dissolved at the anode as is deposited on the cathode. An easily soluble salt should therefore be employed, and the anode should be chosen of proper size and form. As Messrs. Burgess and Hambuechen point out, the lower the current density at the anode, the more nearly does the amount of metal corroded correspond to the electrochemical equivalent, and especially is this the case with nickel. A nickel anode should present as large an active surface to the electrolyte as possible.

It has long been found in practice that ordinary nickel sheets are not suitable as anodes in an electroplating bath, and

that it is necessary to artificially increase the active surface of the anode. This is, for instance, done by the use of corrugated anodes. But it would be wrong to confuse active surface and real surface, as the term active surface takes the current into account which flows from each point of the anode into the electrolyte. Now, Messrs. Burgess and Hambuechen point out and prove experimentally that the active surface greatly depends on the shape of the anode. The diagrams in their article show this clearly. With a rectangular cross section, the distribution of current is much less uniform over the entire surface, than with an oval cross section; and this proves that while with a corrugated anode the actual surface is increased, the active anode surface is not increased in the same proportion, although sufficiently to give good results in practice.

Messrs. Burgess and Hambuechen point out the practical advantages of the use of oval anodes. While corrosion goes on, the electrode retains its original shape, until reduced to a very thin rod or strip; the amount of scrap from oval anodes is about 5 per cent., while with rectangular anodes there is a waste of about 15 per cent. While oval electrodes may require a greater amount of nickel to be suspended in the tank, the authors believe that this disadvantage is more than compensated by the saving in the less frequent removal of electrodes and the smaller amount of scrap.

ANODIC FORMATION OF INSOLUBLE COMPOUNDS.

Among the Synopsis abstracts of this issue there is an abstract of an interesting paper of Isenburg on a special case of Luckow's method of forming insoluble compounds at the anode. The principle of this method may best be explained by a special example for which we may take the formation of white lead, which is the case dealt with by Isenburg. Of course, a lead anode is to be used and the electrolyte must contain CO_3 ions in order to form lead carbonate, but the main principle of Luckow's method is that the electrolyte should contain another anion besides CO_3 , so that he has a mixture of two electrolytes and a double anodic reaction, the one anion forming the insoluble compound wanted at the anode and the other anion forming a soluble salt. It is an important feature that the second salt formed at the anode should be soluble.

For the formation of white lead a mixture of potassium chlorate and potassium carbonate is used as electrolyte with a lead anode. For the formation of lead chromate a mixture of potassium chromate and potassium chlorate is used with a lead anode. It is an established fact that the formation of the insoluble compounds wanted goes on easily, if the second electrolyte (which when acting on the anode gives the soluble salt) is present in a relatively large proportion. This fact seems at first sight somewhat mysterious and requires an explanation. Why is the second electrolyte, which gives the soluble salt, necessary for the easy formation of the insoluble compound, and why must its concentration be relatively great, compared with that of the first electrolyte, which gives the insoluble compound wanted?

An explanation of these facts was given by LeBlanc and

Bind-scheller in the case of lead chromate, and the same explanation has been found by Isenburg to be valid for white lead. It is that the addition of the second electrolyte has the result that the formation of the insoluble salt occurs at some distance from the anode and not directly on the surface. If it would occur directly on the surface of the anode, a layer would be formed which sticks to the plate and another chemical reaction would begin which is not wanted; for instance, if the lead chromate is formed directly on the surface, it becomes now the active anode and the new electrochemical action is the formation of lead peroxide which is not wanted.

To make this explanation clearer, we may take the case of the production of lead chromate by using a mixture of potassium chromate and potassium chlorate with a lead anode. In the first moment of electrolysis both lead chromate and lead chlorate are formed, and the layer of electrolyte next to the anode becomes poor in chromate anions which were present in a relatively small quantity from the beginning. The very thin coating of lead chromate formed on the anode surface in the first moment is assumed to be washed off, so that we then have a lead anode and next to it a layer of electrolyte containing mainly lead chlorate and potassium chlorate, but no chromate; this layer is in contact with the original electrolyte. It is thus evident that the formation of lead chromate cannot any longer occur directly at the anode surface, because there is no chromate in contact with it. The formation of lead chromate will take place at the boundary surface where the electrolyte layer containing no chromate anions, but lead cations (in the form of lead chlorate) is in contact with the original electrolyte. The insoluble salt which is formed there cannot stick to the anode, but falls to the bottom of the cell, and that is what is wanted. The lead anode surface remains bright and remains lead, and the reaction can go on without disturbance. It seems that if this is the complete and correct explanation, the arrangement of the process could be improved.

It is evident that stirring of the electrolyte should here have a bad effect because it destroys the layer of electrolyte next to the anode and brings chromate again in contact with the anode. On the other hand, stirring would have one good effect, as it would help to wash off from the anode surface the thin layer of lead chromate which must be formed in the first moment. There should therefore be noticed bad and good effects when the electrolyte is circulated. Isenburg made some experiments in this direction, but could not get conclusive results; the matter becomes evidently greatly complicated. It is, however, evident that the subject is of great interest and importance, and if the above explanation should prove to be correct, the trick on which Luckow's method is based could find many useful applications.

ELECTROLYTIC PRODUCTION OF BLEACH LIQUORS.

In our former issues the Digest of electrochemical patents prior to July 1, 1902, has dealt with the electrolysis of chloride solutions for the purpose of obtaining therefrom chlorine, and the hydrate of a metal, generally caustic soda. The problem, therefore, has been how to separate, and how to maintain separated, the anode and cathode products. This has been

accomplished in many ways: by absorbing the cation in mercury; by causing the anion to form an insoluble compound with the metal of the anode; by diaphragms interposed between the electrodes; and by special cell constructions in which dependence is placed upon the movement of the electrolyte or upon the difference between the specific gravities of the products. These cells are essentially complex.

The Digest now turns to cells for the production of bleach liquors, and there is found a radical departure in principle and structure; for in general the bleach liquor is a hypochlorite, and is produced by the reaction of the anode and cathode products, as sodium hypochlorite by the action of chlorine upon caustic soda. This reaction is generally permitted to occur within the electrolytic cell, and is facilitated by the juxtaposition of the electrodes and the relatively rapid movement of the electrolyte. The necessities of proximity and parallelism of the electrodes, less resistance, and simple electrical connections indicate the peculiar adaptability for this purpose of the series system of electrode connections.

ELECTROLYTIC AND METALLIC CONDUCTION.

At the recent New York meeting of the American Electrochemical Society the proper definition of metallic and electrolytic conduction was the subject of quite an extended discussion. In general, there cannot be any doubt how to distinguish between metallic and electrolytic condition. If a current flows through a wholly metallic circuit, there is no chemical change; if it flows through a circuit containing an electrolyte with electrodes, there is a distinct chemical change at the electrodes, consisting of oxidation and reduction. But if we have an electric circuit wholly made up of electrolytes without any metals, then if a current flows through it, there is no possibility of oxidation and reduction; there is no possibility of the ions giving off their charges. Nevertheless, there is no reason whatever to assume that in this case the mechanism of the conduction in the interior of the electrolyte is in any way different from the mechanism of conduction when electrodes are used. It was correctly said by one of the speakers in the discussion of Mr. Marvin's paper that the movement of the ions in the interior of the electrolyte is governed alone by the force acting on them at that place (*i. e.*, by the electric drop of potential at that point and by the osmotic force) and by nothing else; the ions "do not know" whether there are electrodes in the circuit at some distance or not; the movement of the ions at a special point in the electrolyte depends on the electric field at that point and it does not matter whether this electric field has been produced with or without electrodes at some distance.

The experiments described in Mr. Marvin's paper, which was abstracted at some length in our last issue, are quite interesting; they prove the existence of an alternating current in a wholly electrolytic circuit. This might perhaps be proven even in an easier way by setting up eddy currents in an electrolyte by means of an external circuit and proving the existence of these eddy currents by measurements of the power consumed when the eddy currents are produced and when the electrolyte is taken away. This might give a method of measuring the conductivity of a solution without the use of electrodes.

UNION ENGINEERING BUILDING.

A meeting of the chosen representatives of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and the Engineers' Club, was held in New York City, May 15th, to discuss the proposed gift of \$1,000,000, by Mr. Andrew Carnegie, for a union engineering building.

There were present Messrs. Dodge, Dwight, Fletcher, Hunt, Hutton, Kafer, Kirchhoff, Ledoux, Martin, Noble, Pegram, Redding, Scott, Wilgus. Mr. Charles F. Scott was chairman, and Prof. F. R. Hutton, secretary of the meeting. After a very harmonious and extended discussion the following resolution was passed unanimously:

Resolved, That this Joint Conference Committee recommend to the respective governing bodies represented at this conference, that the following resolutions be brought before the several organizations to be acted on:

Resolved, That (insert name of organization) unite with (insert the names of the other four organizations), or any of them, for the purpose of accepting the sum of \$1,000,000 as a gift from Mr. Andrew Carnegie, for the purpose of erecting suitable buildings for occupancy by various societies of engineers and the Engineers' Club, on the sites secured for that purpose on the north side of Thirty-ninth street, and south side of Fortieth street, west of Fifth avenue, in the city of New York, in the State of New York; and

Resolved, further, That (insert name of organization) has a very high appreciation of this generous gift of Mr. Andrew Carnegie, and this additional evidence of his recognition of the engineering profession and his deep interest in the welfare of the national societies of engineers and the Engineers' Club; and

Resolved, further, That a site on the north side of Thirty-ninth street shall be purchased and held by trustees, or otherwise, as shall be determined by the Joint Committee hereinafter mentioned for the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers, or by such of them as shall vote in favor of coming into this enterprise; and

Resolved, further, That a joint committee shall be created to be composed of three members of each organization that shall unite in accepting said gift of \$1,000,000 from Mr. Andrew Carnegie; and that the governing body of (insert name of organization) shall elect three members of this organization to represent it on and be members of such joint committee; and that the governing body of (insert name of organization) shall have the right and power to remove any member of such joint committee who shall be elected by it, and to elect any member of this organization to fill any vacancy that shall occur in such joint committee by reason of the death, resignation, refusal to act or removal of any member who shall have been elected by the governing body of this organization as a member of such joint committee; and

Resolved, further, That the character and internal arrangement of the building to be erected on the site on Thirty-ninth street, shall be determined upon by the affirmative vote of at least two-thirds of all of such of the members of said joint committee as shall represent all of the organizations, other than the Engineers' Club on such joint committee, and that the character of the internal arrangement of the club building to be erected on the site on Fortieth street, shall be determined upon by the affirmative vote of all of the three members of such joint committee who shall represent the Engineers' Club on such joint committee; and

Resolved, further, That said joint committee shall, by the affirmative vote of at least two-thirds of all the members thereof, select and employ an architect to prepare the plans and specifications for the building to be erected on the site on Thirty-ninth street, and for the club building to be erected

on the site on Fortieth street; and shall also obtain proposals for the erection of both of such buildings; and shall have power to make and enter into such contract or contracts as shall be approved and authorized by the affirmative vote of at least two-thirds of all the members of said joint committee, for the erection of both of such buildings; and shall have charge of the erection of both of such buildings; and

Resolved, further, That said joint committee shall continue in existence until all of the purposes set forth in these resolutions shall have been fully accomplished.

The secretary was authorized to transmit a copy of the above resolutions to each chairman of the constituent committee present, with a request that the latter should transmit the action of the meeting to the governing body of each respective society.

NIAGARA FALLS MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The annual convention of the American Institute of Electrical Engineers will be held at Niagara Falls, N. Y., June 29th to July 3d. The mornings from 9.30 to 1.30 will be devoted to the presentation of papers, while the afternoons and evenings will be devoted to the inspection of places of technical and historical interest. Excursions to various localities in Niagara Falls and Buffalo will be arranged for the members of the Institute and their guests.

Papers for the convention will be presented in the following order: On Monday morning, Mr. C. F. Scott will deliver his presidential address, to be followed by papers and discussions relating to the scope and development of the Institute, with particular reference to the organization of local branches. The topics of the papers for Tuesday morning will be "Electric Traction," for Wednesday, "Long-Distance Power Transmission," and on Thursday, papers on miscellaneous other subjects will be read. Among the papers announced there are the following: "The Storage Battery in Sub-Stations," by W. E. Goldsborough and P. E. Fansler; "The International Electrical Congress of 1904," by Elihu Thompson; "Symbols and Nomenclature," by Carl Hering; "The Magnetic Units," by Dr. A. E. Kennelly; "The Legalized Standard of Electromotive Force," by Prof. H. S. Carhart; "Institute Branch Meetings, their Organization, Development and Influence," by Calvin W. Rice.

Mr. H. W. Buck, of the Niagara Falls Power Co., has been appointed Chairman of the Niagara Falls Local Committee, and will have general charge of all local details. The transportation arrangements are in the hands of a committee, with Mr. E. H. Mullin, 44 Broad street, New York, as chairman.

FALL MEETING OF THE AMERICAN ELECTRO-CHEMICAL SOCIETY.

As it has been found impracticable to hold the fall meeting of the American Electrochemical Society at Boston, as originally planned, Niagara Falls will probably be the place selected for the meeting. The intention is to hold the spring meeting next year in Washington, and the fall meeting at St. Louis. The Mayor of St. Louis, and the Business Men's League, of the same city, have already sent official invitations to the Society.

AMERICAN INSTITUTE OF MINING ENGINEERS.—We have received from the secretary of the Institute advance copies of the following papers: "Some Practical Suggestions Concerning the Genesis of Ore Deposits," Bohmer; "Operations of the Hudson River Water Power Co.," Parsons; "Zinc and Lead Deposits of Northern Arkansas," Adams; "Note on the Influence of the Rate of Cooling on the Structure of Steel," Sauvour and Boynton; "The Geographical and Geological Distribution of the Mineral Deposits of Mexico," Aguilera; "Ore Deposits Near Igneous Contacts," Weed.

THE COMPOSITION OF ELECTROPLATING SOLUTION.

Some interesting notes on this subject are given in a paper presented by DR. N. S. KETCH at the New York meeting of the American Electrochemical Society. In the following we give an abstract of this paper:

In an electroplating bath with soluble anodes, the metal dissolved from the anode should be substantially equivalent in quantity to the metal deposited on the cathode, the composition of the bath remaining practically unchanged. This ideal condition is never fully attained in practice.

In electroplating and electrotyping the anodes should be of the pure metals, otherwise the impurities will either enter the electrolyte, thus changing its constitution, or they may, if insoluble, form crusts on the anode, consisting of insoluble and non-conductive salts.

An example of the first case is that from a copper anode containing iron, in a copper sulphate solution, iron will be dissolved, more copper will be deposited on the cathode than is dissolved from the anode. In this way the constitution of the electrolyte is progressively changed, until finally it becomes unfit for use.

An example of the second case is that if there be lead in the anode, a lead sulphate is formed thereon. If in considerable quantity, there may be a partially-insulating coating on the anode, which obstinately adheres thereto or falls off from time to time. But in this case, as in the former, the integrity of the electrolyte is gradually destroyed.

In cases where there are metals which are electronegative to the copper of the anode, there is a local electrolytic action by which copper is dissolved beyond the equivalent due to the operative current and to the deposit on the cathode, so that the electrolyte is unduly enriched.

In the operation of electrolytically refining copper all of these conditions exist; therefore the electrolyte has to be more or less frequently regenerated by change in quantity of one or more of its constituents, or discarded altogether for new.

The ideal electrolyte, wherein metal is to be transferred from the anode to the cathode, is a solution of that metal which has no corroding effect on either the anode or cathode when no current is flowing through the cell. Such a solution may possibly be made, but is maintained with difficulty during operation. For instance, a neutral cupric sulphate solution has, unaided, no appreciable effect on pure copper, but under action of current, except of quite low density, coatings of a basic sulphate form on the anode, and for a time more copper is deposited than is dissolved. Then, in order to pass current, an increase of voltage is necessary. Then follows a deposition of hydrogen on the cathode, with an equivalent oxidation of the anode without corresponding solvent action.

If the cupric sulphate solution be acidified by addition of H_2SO_4 , then the current density may be increased, because there is more of the anion quantity available. But it may be necessary to increase the quantity of Cu, so that the cation quantity may be equal to the extent of fully satisfying the requirements of the density of current. Otherwise H will be deposited with the Cu, and the electrolyte depleted of its essential constituent, Cu.

Agitation of electrolytes is necessary in operating with high densities of current, in order to have abundant supplies of the suitable ions at their proper places at the surface of the electrodes, heat assisting both agitation and solvent action.

The foregoing considerations justify the conclusion that the use of strong solutions as electrolytes, with abundant solvent of the salt formed at the anode and rapid agitation or circulation, will allow of great densities of current, insuring rapid deposits of metal. These interdependent conditions, properly balanced and operated, will insure also the desired quality of deposit within the characteristic possibilities of each metal as to its crystallinity or its amorphous condition.

The author discusses gold plating, with the use of a solution

of gold cyanide in a solution of potassic cyanide. This is generally worked while hot. Now, gold is not, contrary to general acceptance, dissolved by a solution of potassic cyanide. But auric cyanide is. To dissolve gold in a solution of potassic cyanide without electric current, it is necessary to furnish some element to displace the CN of the KCN, so that it may be free to unite with Au to form AuCN. This element, in practice of cyaniding gold ores, is oxygen. If only half of the necessary oxygen be supplied, there is a further change, involving the decomposition of some of the water of the solution. It will readily be seen how essential is the presence of oxygen. By exposure to air, such a solution absorbs oxygen, and thus becomes a ready solvent of gold from both electrodes, thus changing the solution. Under current, CN is the anion, and acts directly to unite with the gold of the anode. But such a solution is worked with a high voltage and high density of current, for practical results, with a strong evolution of both oxygen and hydrogen.

To preserve the integrity of the electrolyte, in so far as its contents of gold is concerned, the electroplater varies the area of the anode, making it more or less to increase or decrease the contents of gold so dissolved; generally by guess, under the "rule-of-thumb," guided somewhat by experience. The cathode is kept in constant, rapid motion to remove the bubbles of hydrogen, so that the gold cation may have access to the cathode surface. Such coatings of gold have quite imperfect adhesion, especially on metals which are electropositive to gold in cyanide solutions. To obviate this defect as much as possible, the operator makes the necessary electrical connections to the electrodes before immersing the cathode in the bath.

Gold is seldom deposited to any thickness exceeding one-tenth thousandth of an inch, and oftener not more than one hundred thousandth of an inch. Such a deposit cannot be considered a protective coating for a great length of time, even under ordinary atmospheric conditions, and not at all under the action of corrosives of the metallic body which it overlies.

No matter how well the article may have been cleaned*, or how well it may have alloyed with the gold†, or been bombarded‡, the deposit is porous and the metal underneath is still subject, though in a lessened degree, to the action of corrosive gases and liquids. The oxides, chlorides, nitrates and sulphides thus formed at the exposed places on the baser metal require more room, so they exude, creep under the coating and spread themselves over it, so as to, in time, completely hide the gilding. Thus it may be mistakenly thought to have found its way, as an alloy, into the substance of the baser metal. Etching will dissolve the oxides, etc., and again expose the gold on the surface of the article§.

No matter how nearly perfect an electroplating solution may be, nor how skillfully operated, the deposit increases in roughness with thickness. In electrosilvering the operator from time to time removes the cathode, and smooths the deposit by "scratch brushing" with a brush made of metallic wires. He is thus enabled to secure any desirable thickness of deposit of silver and a thoroughly protective coating, because he closes the pores of the deposit by the burnishing action of the brush.

Those solutions used in the transfer of metals, which contain no free acid of the kind which is a constituent of the salt of the metal transferred, are the most permanent and least liable to decomposition in operation, provided that salt is readily soluble in the liquid and that liquid has no action, by itself, on the metal. As an example, the author remarks that some years ago he began a series of experiments having for their object the refining of lead base bullion, and separating its contents of gold and silver by electrolysis. His first work was done in solutions of lead acetate and of lead nitrate (U. S. patent No. 209,056, 1878). But the integrity of such solutions could not be maintained. They were gradually decomposed

* Burgess & Hambuechen in *Electrochemical Industry*, Vol. I, p. 204.

† Kahlenberg in *Electrochemical Industry*, Vol. I, p. 201.

‡ Johnson in *Electrochemical Industry*, Vol. I, p. 212.

§ Kahlenberg in *Electrochemical Industry*, Vol. I, p. 201.

with the formation of basic salts, insoluble on both anode and cathode, and some soluble in the liquid. The deposits then became unsatisfactory. Such solutions in the cases of all metals are impracticable for continuous work on a large scale. Like effects are the result in working cyanide solutions if the cyanogen constituent is not, from time to time, renewed. The author overcame this defect in the process of refining lead by using as a vehicle for the transfer lead sulphate, and as a roadway a solution of sodic acetate, in which lead sulphate is readily soluble (U. S. patent No. 215,463, 1879). The anion SO_4 readily attacked the lead anode, and the solution of sodium acetate at once dissolved the lead sulphate. In this solution, without access of oxygen, lead remains bright and unattacked. Under the action of current of reasonable density, its integrity is preserved indefinitely. The same amount of lead is deposited as is dissolved, and no gases are evolved. The acetate of soda remains unchanged.

The general tendency in electroplating solutions in operation is to form oxy-salts at the anode. Or, in other words, oxygen becomes an active anion to act jointly with the acid anion of the salt, which is the true vehicle by which the transfer is made. This is undesirable, and if avoided, either by suitably composing the solution or by properly operating it, the best results will be attained.

MODERN ELECTROLYTIC COPPER REFINING.

In his paper on this subject, read at the New York meeting of the American Electrochemical Society, Mr. TITUS ULKE calls attention to the great difficulty of obtaining absolutely reliable data regarding many electrolytic refining processes and plants, on account of the peculiar secretive policy adopted by most electrolytic refining companies. The author holds, with Dr. Douglas, that the managements of copper-refining companies might profitably adopt the methods of the American iron and steel makers and allow engineers free access to all parts of their plants, and thereby encourage a free exchange of ideas and the obtaining of mutual benefits, which are generally of far greater importance than any temporary advantage gained by secretive methods.

There is very little to choose between one brand of electrolytic copper and another. All are good, and all have been brought to that high standard by expert labor and expert experience of instruments in expert establishments; whereas had there been co-operation on points of purely technical manipulation, the same results would have been obtained at infinitely less expense. The author has inspected most of the refineries in this country and abroad, and claims that all the so-called mysteries of electrolytic copper refining may be resolved into certain, now more or less well known, simple rules of practice.

The material at present subjected to profitable electrolytic treatment in the world's copper refineries is invariably a precious metal-bearing crude copper, cast into anodes assaying at least 96 per cent. Cu, with only one or two unimportant exceptions, and generally refined by fire methods up to 98 or 99 per cent.

The initial cathode sheets, or starting plates, of plants arranged according to the multiple system, are invariably thin sheets of electrolytic copper, obtained by deposition upon and stripping from greased, oiled or varnished plates of either copper or lead. The commercial cathodes are allowed to reach a thickness which is generally fixed at 0.5 to 0.75 inch in the multiple process, and 0.25 to 0.45 inch in series arrangements.

Solutions containing not less than 12 per cent. and not over 20 per cent. bluestone, and from 4 to 10 per cent. free sulphuric acid, are employed almost universally. It is very important that the constantly-decreasing acidity and the constantly-increasing copper contents of the electrolyte be maintained within these limits. A small quantity of common salt or

magnesium chloride, or, better, hydrochloric acid (say, 300 cc to a tankful of solution), is always added upon commencing operations, in order to hinder any possible dissolving of silver and to prevent "sprouting" or brittleness of the cathodes or starting sheets. Ammonium sulphate is sometimes added to the solution when considerable arsenic is present. Heating the electrolyte up to between 40° and 50° C. is advantageous, because it decreases the electrical resistance of the solution and increases the tensile strength of the copper.

Current densities ranging from 4 to 45 ampères per square foot of cathode surface are employed, the ampérage used depending chiefly on the cheapness of power, the grade of the anode in silver and impurities, and the purity of the electrolytic solution.

The voltages measure from 0.1 to 0.3 volt between each row of plates in series tanks, and generally from 0.2 to 0.4 volt between the tanks when the plates are arranged according to the multiple system.

The following products of refining are marketed: Commercial cathodes, which are occasionally shipped to the consumer as such, but are generally cast into wire bars, ingots, cakes or slabs of standard dimensions and weight. They usually assay from 99.86 to 99.94 per cent. Cu. The yield in commercial cathodes is 97 to 99 per cent. of the weight of anodes treated, barring the anode scrap, which ranges from 7 to 15 per cent. of the anode weight in multiple plants to as much as 30 per cent. (probably) in a certain refinery with electrodes arranged in series circuit. About 1 to 3 per cent. of the copper treated is generally recovered as blue vitriol. Besides electrolytic copper and bluestone, many refineries produce fine silver and fine gold, together with some base bullion from the anode slimes; and occasionally nickel salts, arsenious acid and tellurium, which products are recovered in purifying or working up the foul electrolytes.

A comparison of the methods and appliances used to-day with those employed only ten years ago shows that many important improvements have been made, nearly all of which are of American origin, and resulted from the necessity of handling large outputs. The chief improvements, in the author's opinion, are the substitution of casting machines for hand ladling; the employment of mechanical conveyors and of pneumatic tongs or hooks for charging pigs into the anode furnaces; charging machines designed for the same purpose; improved anode molds and shape of anodes; the introduction of electrode-handling cranes for charging the entire tankload of plates at one operation; greater facilities for handling material in the shape of locomotives, trucks and tracks; improved form and construction of solution pumps; improved disposition and operation of tanks, so as to increase their capacity with the same floor space; improved design and support of tanks, so as to increase their life and at the same time permit of their ready inspection for leaks; arrangement of plant with head room below the tanks, so as to allow of a ready removal of the silver slimes from the tanks and to the silver refinery; improved circulation devices, applicable in special cases; standardization of the conditions in refining, due to a better knowledge of the chemical and physical conditions involved; increase of current densities; better checking of the chemical and mechanical properties of the electrolytic copper; simplification of the testing methods in the chemical and physical laboratories, and a general increased efficiency of plant and reduction of operating costs.

The author then gives statistical data on copper refineries from his "Copper Refining," which is to be issued shortly. Most of his statistical figures have already been noticed in *ELECTROCHEMICAL INDUSTRY*.

The United States now produces electrolytic copper at the enormous rate of 278,860 tons per year, which, at \$260 per ton, is valued at over \$72,000,000.

ANODES FOR ELECTROPLATING.

By PROF. C. F. BURGESS AND CARL HAMBUECHEN.

An ideal electroplating process employs a combination of electrodes and electrolyte, such as will enable a firm adherent coating to be deposited upon the cathode without the electrolyte undergoing a change in composition. This requires that the metal shall be deposited in electrochemical equivalent quantities, and that the same amount shall go into solution at the anode. In most of the industrial electroplating operations, this requirement is difficult to fulfill, and the departure from ideal conditions necessitates employment of skill and constant attention of the operator to ensure uniformity of product. One of the chief sources of difficulty is at the positive electrode, and it is becoming appreciated by platers that attention given to the anode aids in obtaining satisfactory results at the cathode. The shape, structure, physical properties and the chemical composition of the anode are all factors which may largely influence the results.

If, as is frequently the case, the metal of the anode does not go into solution in proportion to the electrochemical equivalent, the solution becomes deficient in metal and requires the addi-

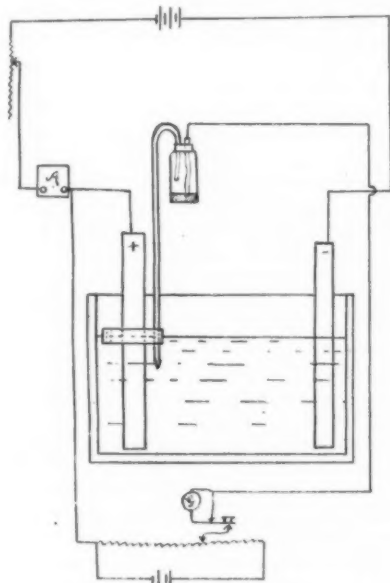


FIG. 1.—METHOD OF MEASUREMENT.

tion of certain chemicals to restore it to its original and working condition. It is the purpose to point out here some of the factors which influence the corrosion at the anode and to give the results of some measurements which have been made upon nickel anodes in a nickel-ammonium sulphate plating solution.

It may be stated as a general principle that the lower the current density at the anodes, the more nearly does the amount of metal corroded correspond with the electrochemical equivalent, and especially is this the case with nickel. With the commercial forms of this metal, the current density must be kept below 5 ampères per square foot in order that a high current efficiency of corrosion may be attained. This, in turn, requires that the anode should present as large an active surface to the electrolyte as possible. It has been found that flat plates of nickel arranged along the sides of a plating tank do not present sufficient active surface to enable a suitably low anode current density to be used, and at the same time to deposit nickel upon the cathode as rapidly as may be desired. To overcome this defect, various improvements have been introduced to increase the amount of active anode surface. Among these improvements are corrugated anodes and the round or oval anode.

It is held by some that a porous metal casting having a coarse crystalline structure will corrode more rapidly than will a dense metal anode, and while this may be the case, there is introduced the disadvantage that the corrosion proceeding between the particles of the metal may cause pieces of some considerable size to become detached from the anode without being corroded, thus causing a considerable waste of nickel. A firm, dense casting gives a more uniform and even corrosion, and is, therefore, preferable to the porous castings.

The term "active anode surface" does not mean merely the area of surface which is exposed to the electrolyte, but rather the area exposed to the electrolyte from which current readily flows. The shape of the anode has much to do with the active anode surface as will be shown in the following diagrams.

Measurements were made upon nickel anodes suspended in nickel plating tank to determine the relative amounts of cur-

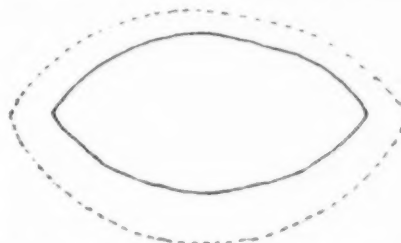


FIG. 2.—DIAGRAM SHOWING THE VARIATION OF CURRENT DENSITY OVER THE SURFACE OF THE ANODE.

rent flowing from each portion of the anode surface, anodes of two different types being used. One of them was the ordinary flat electrode, having the dimensions 6 x 9 inches, by 1/2 inch thick, and the other electrode had an oval cross section 2 1/2 inches long and 1 1/4 inches thick. While the measurements were being made, the anode was placed 1 inch from the side of the tank opposite a cathode, the distance between the anode and the cathode being 6 inches.

The method employed in making the measurements is illustrated in Fig. 1. The anode was fitted with a block of wood dipping just below the surface of the electrolyte. Through this block, holes were drilled at uniform intervals around the anode and 1/2 inch away from it. Through these holes the liquid terminal of a "calomel normal electrode" was introduced, and by measurement of potential between the mercury terminal and the anode terminal the fall of potential caused



FIG. 3.—DIAGRAM SHOWING THE VARIATION OF CURRENT DENSITY ON THE ANODE SURFACE.

by the current flowing through the electrolyte was derived. The differences of potential were measured by the potentiometer method. The current flowing from each portion of the anode was adjusted so that a current density of about 5 ampères per square foot of exposed surface was obtained.

By determining the difference of potential between the anode and the normal electrode and deducting the contact potential of the electrolyte and electrode, the fall of potential through the electrolyte was obtained, and the current flowing was, therefore, proportional to such values. In this way the relative amount of current flowing from each portion of the electrode surface was obtained. The results are plotted in Figs. 2 and 3, the amount of current being proportional to the distance from the electrode surface to the dotted curve. With the rectangular cross section, it is seen that the distribution of current is much less uniform over the entire surface than where the anode of oval cross section is used. In the former, the part

of the electrode nearest the side of the tank undergoes very little corrosion and, consequently, that portion of the surface can hardly be considered as "active electrode surface." To make the curves as nearly comparable as possible, the cathode surface was in each case made about twice as large as the anode surface.

The shaded portion of Figs. 2 and 3, indicating the distribution of current, show, also, the manner in which corrosion takes place and the manner in which the electrode will be worn away. With oval electrode, the corrosion will take place in such a manner that the electrode retains its original shape, although, of course, decreasing in size, the corrosion continuing until the electrode is reduced to a very thin rod or strip. In addition to having a larger ratio of active to total anode surface with the oval than with the rectangular electrodes there seems to be the further advantage that the corrosion may proceed in the former until a larger percentage of the material has been used up before it becomes necessary to replace it with a new anode.

From the results of measurements made in an electroplating plant where both these forms of anodes have been in use, the following results were noted: An oval anode, the original weight of which was 11 pounds, had corroded until $1\frac{1}{2}$ pounds remained, and the anode still retained its original shape and was capable of furnishing more metal to the solution. The necessary waste from this electrode, due to the method of suspension, was about $\frac{1}{2}$ pound, so that the amount of scrap from such anodes may be figured at about 5 per cent. With rectangular anodes the original weight of which was 16 pounds, there was a waste of about $2\frac{1}{2}$ pounds after the anode had become so far corroded that it had to be removed from the tank. This represents a waste of about 15 per cent. Inasmuch as the original anode material costs about 50 cents per pound, and the scrap nickel can be disposed of at about one-half that value, the amount of scrap represents a loss to the plater of about 25 cents per pound and is an item well worth attention.

With the anodes tested, the oval ones had a surface of about 6 square inches per pound of material, while the rectangular ones had a surface of about 14 square inches per pound. Inasmuch, however, as in the latter case, the surface exposed is not all active surface, while in the former case the proportion of active surface is much greater, these figures do not represent the relative amount of active area per pound. The desideratum of the electroplater is not to obtain a large active surface per pound of metal, but rather, obtain as much active surface per foot length of tank as possible. While oval electrodes may require a greater amount of nickel to be suspended in the tank, the disadvantage is only in the increased interest on the investment, and this item is more than compensated by the saving in the less frequent removal of electrodes and the smaller amount of scrap. A further advantage in the oval electrodes is the fact that a more dense casting may be obtained than where the electrodes are made flat and thin.

The corrugated electrodes present an advantage over the flat ones in exposing a greater amount of active electrode surface, but the active electrode surface is not increased in direct proportion to the actual electrode surface exposed to the electrolyte. This is due to the fact that the current does not leave the low parts of the corrugations as readily as it does the elevated points, due to the greater distance from the cathode and the less free circulation of the solution around the lower parts.

From the measurements and observations above described it appears desirable to subdivide the anode metal into rods or strips of such form that corrosion can proceed on all sides. It should be noted, however, that even with such subdivision the corrosion will not take place from the side of the anode away from the cathode unless the anode rods are placed a sufficient distance apart to allow free circulation of solution and flow of electric current through it.

NICKEL CATHODES.

By DAVID H. BROWNE.

The simplicity and convenience of preparing a copper cathode by the electrodeposition of the metal upon a sheet of lead, from which the coating is stripped when it has attained the desired thickness, is so obvious that much time and labor have been spent in attempts to prepare a similarly soft and flexible cathode sheet for use in nickel refining.

While such attempts are not of commercial importance, since a rolled cathode of nickel is much preferable to the deposited article, yet these researches are useful from the side lights which they throw on the character and properties of electrolytic nickel.

The bugbear encountered by all who attempt to produce sheets of nickel thicker than that used by nickel platers has been the tendency of nickel to crack and curl off in rolls, like wood shavings. This very analogy of the wood shaving helps us to understand the reason of the peeling of nickel. The reasons which I advance may or may not be borne out by theory, but they are readily proved by practice. The wood shaving curls into a helix because it is compressed on one side or expanded on the other. A similar difference in surface tension causes the curling of nickel deposits.

Suppose that the cathode be 10 centimeters square, and the distance between anode and cathode is also 10 centimeters. A liter of solution lies between the electrodes, and in this, in the common nickel ammonium sulphate bath, there are about 13 grams nickel. Now, suppose that the cathode be laid flat and this solution poured upon it till it commences to run off. The probable thickness of this wetting film is, say, for example, 1 millimeter. This figure is used only for argument's sake, but it gives us, as probably under the molecular attraction of the cathode at any one time, about a tenth of a gram of nickel. How much of this nickel is in the form of ions, free to deposit upon the cathode, is an unknown factor. Certainly, much less than a tenth of a gram.

Imagine now that all the free ions of nickel in contact be plated upon the cathode, and the solution be at rest. The film of solution in cathode contact rises, and in part diffuses back into the solution behind it; that is, toward the anode. If we imagine the current divided into impulses, we must see that the second impact of current has a lesser number of ions to act upon, and these, when deposited, are scattered and not contiguous. The next deposit comes down in still more scattered spots, and, as each particle of nickel attracts its neighbor, there arises a surface tension which finally exceeds the tensile strength of the metallic film and the air pressure which holds the film on the cathode. At this point the deposit cracks and curls anodeward.

On examining the fracture of a nickel cathode, which has been plated to a thickness of about an inch, it is seen to consist of a dense forest of small hairs, like the pile of velvet. Each hair is of the same thickness throughout, and each in contact with its neighbor. A poor cathode shows the hairs ending in a loose, irregular, mossy deposit, readily scraped off. The solid deposit is solid because there was brought into cathode contact sufficient ions to replace those thrown out by the current, so that at no time was the deposit impoverished and the growth of the fibers stunted. Just as a sheaf of wheat is smaller at the top than at the bottom, and just as velvet tends to curl toward the pile, so does the poor nickel deposit tend to curl toward the anode.

It is evident, then, that any condition which aids the replacement of the ions helps the deposit to remain flat. Circulation is, in this respect, most efficient. With a difficultly soluble salt no replacement, however fast, is certain to prevent local irregularities. Hence the use of more soluble salts, as nickel chloride, is of great benefit. Heat also, by giving mobility to the liquid and by causing eddies therein, is a useful ally. More than all is the employment of a steady density, since it is self-evident that a deposit hurled at the cathode with a cur-

rent density of 200 or 300 ampères per square meter must be different in its physical structure from that allowed to fall out of solution at a density of 50 or 75 ampères.

There is no secret about the production of solid nickel deposits of almost any desired thickness. The entire art consists in maintaining initially good conditions to the end.

The ordinary nickel plater hangs an object on a cathode bar, turns on a current, which is never measured; pulls the cathode out to see how it looks; puts it back and takes off some other article which is sufficiently plated. Meanwhile the solution is practically at rest. It is foul with all kinds of floating oxides; it has never been analyzed, nor tested, nor filtered. The cathode deposit has absolutely no chance to attain a respectable thickness, and if it were not for the great hardness of electrolytic nickel, which enables an exceedingly thin deposit to withstand rough usage, nickel plating would rapidly become a lost art.

Applying this rule to the production of thin sheets of nickel, the deposition from sulphate solutions offers no difficulty. Given a highly-graphited copper or tinned-iron cathode, a solution or neutral nickel sulphate or nickel ammonium sulphate, kept about 50° C., a pure nickel anode and an efficient system of circulation—with these conditions a deposit started at any density, from 50 to 300 ampères per square meter, can be carried through at the initial density, and will produce a smooth, slightly-mammellary sheet, which, on releasing one corner with a knife blade, will strip spontaneously and lie flat. Such a deposit is, however, glass hard and very springy, and, unless annealed, cannot be bent over a hanger.

Before it was discovered that a rolled nickel cathode was in every way preferable to a deposited cathode, much time and labor were expended by Mr. L. R. Vorce and myself on the production of flexible nickel sheets. As a chloride solution was in use in the plating baths, it was thought advisable to use a similar solution for the cathode deposits. Early experiments showed that pure nickel chloride gave such an intensely hard and brittle metal that it was difficult to strip, and, after repeated trials, a solution containing about 90 grams nickel chloride and 170 grams common salt per liter was taken as the basis of experiment. Working from this solution, some interesting experiments on the effect of acidity, heat, current density and solution density were undertaken.

The choice of cathode upon which to deposit narrowed down to copper, lead, tinned iron and block tin. Of these, copper was discarded as liable to foul the solutions. Tinned iron gave such a smooth deposit that the second plating would not adhere, while lead caused too firm adherence between cathode and deposit to be satisfactory. A graphited cathode of rolled block tin was in every respect found satisfactory. The sheet was prepared by painting an inch-wide border of P. & B. paint around the edges. Within this the tin surface was discolored by an exceedingly thin coating of the same paint, dissolved in bisulphide of carbon, or any other thinner. Over this discoloration fine graphite was rubbed, to form a stripping surface. As the nickel separates from this surface very readily, it was found necessary to scrape off the graphite for a width of about an eighth of an inch within the painted border, thereby leaving a bare edge, to which the deposit adhered.

On such a cathode small sheets, say, 6 inches square, which will be flat when stripped, are readily prepared. With sheets about 18 x 24 inches the difficulties are much greater, on account of the increased surface over which uniform conditions must be maintained. The first test made was for solution density.

DENSITY OF SOLUTION.

M solution, 70 grams NiCl₂, 180 grams NaCl per liter.

N solution, 90 grams NiCl₂, 180 grams NaCl per liter.

O solution, 110 grams NiCl₂, 180 grams NaCl per liter.

All solutions kept at 75° C.; cathode, 36 square inches; 60 ampères per square meter; 360 ampères used. All deposits were good, but sample M was the most flexible.

HEAT.

P solution, 70 NiCl₂, 180 NaCl at 70° C.

Q solution, 70 NiCl₂, 180 NaCl at 90° C.

R solution, 70 NiCl₂, 180 NaCl at 103° C.

The flexibility increased with the temperature. In practice, however, 70° C. was easiest to maintain.

CURRENT DENSITY.

A solution, 70 gram NiCl₂, 180 NaCl, 70° C., 32 amp. sq. m.

B solution, 70 gram NiCl₂, 180 NaCl, 70° C., 83 amp. sq. m.

C solution, 70 gram NiCl₂, 180 NaCl, 70° C., 116 amp. sq. m.

D solution, 70 gram NiCl₂, 180 NaCl, 70° C., 220 amp. sq. m.

E solution, 70 gram NiCl₂, 180 NaCl, 70° C., 270 amp. sq. m.

F solution, 70 gram NiCl₂, 180 NaCl, 70° C., 345 amp. sq. m.

A was gray and speckled, with dark spots; was flexible, but would not bend right angles; annealed well.

B was whiter, and fairly flexible; annealed well.

C was bright and white, flexible, and annealed well.

D, light gray, very smooth; annealed beautifully.

E, very white and smooth, and also annealed very well.

F, dark color; curled and cracked off.

ACIDITY.

G, same solution and temperature, 250 amp. M² neutral.

H, same solution and temperature, + 0.1 per cent. HCl.

I, same solution and temperature, + 0.2 per cent. HCl.

G was very white, smooth and flexible.

H, rough, light gray and covered with hydrogen points; was brittle, and would not bend to right angle.

I was dark gray to black, with hydrogen streaks, and very brittle.

We have, therefore, the following indications:

First. Neutrality of solution.

Second. Heat increases flexibility.

Third. Solution about 70 NiCl₂, 180 NaCl per liter.

Fourth. Current from 100 to 200 ampères per square meter.

Fifth. Efficient circulation.

These conditions have given in practice very fair results. All cathodes made in this way have, however, a slight outward curl, which curl increases with the current density. Cathodes about 18 x 24 inches, made at 60 ampères, would curl about 2 inches out of plane, while those made at 200 ampères would roll up into a coil. The curling was always anodeward and around the longer axis of the cathode, irrespective of the way in which the cathode hung in the bath.

Square cathodes curved either way—that is, about either central line—according to which way pressure was applied.

A test was made to determine the extent of curvature given by a certain current. This being established, an anode was curved to the same radius, and a cathode was fastened to a backing of the same, but reversed curvature. The plating was now performed in exactly the same manner as before. When the cathode had attained the desired thickness, it was stripped from the backing and, as was expected, sprang into a perfect plane surface.

This suggests the employment of a curved cathode to measure the intensity of surface tension of deposits under various conditions, and, as a matter of scientific investigation, such experiments would probably be productive of much valuable information.

PROF. F. HABER ON ELECTROCHEMISTRY IN THE UNITED STATES.

I.

As was announced in these columns at that time, Prof. F. Haber, of Karlsruhe, Germany, visited this country last year, as a delegate of the German Bunsen Society for Applied Chemistry to the American Electrochemical Society. His society also asked him to report on the industrial development of electrochemistry in this country, and on the methods of teaching electrochemistry in our universities. The visit of Dr. Haber extended over a period of sixteen weeks. On his

return to Germany, Dr. Haber gave a summary of what he had seen in America, in a series of lectures held in various German cities before local sections of the Bunsen Society. We are glad to present to our readers in the following rather full abstracts of his lectures, which will no doubt interest many in this country. It is always of interest to learn how others see us, and this is enhanced in the present case by the prominent position which Dr. Haber deservedly holds among the electrochemical scientists of Germany.

Dr. Haber first pays his respects to all those who aided him while on his trip, to all his old and new friends in the United States, and to the American Electrochemical Society, which received him in a very cordial way.

He speaks enthusiastically of the impression which he had when the steamer entered the harbor of New York. "The beauties of nature may be more magnificent in other places, but nowhere have I seen a similar example of industrial activity. This impression grows in the inner harbor and forces aside any other sentiment when one enters lower New York, the forms and means of traffic there exceeding everything that is known to us in the old continent." He points out the differences in the industrial development in the European countries where the older type of culture exists, and in a new country like the United States. In the former the treasures with which they are endowed by nature no longer require to be discovered and an increase of wealth of the nation depends upon larger refinement of engineering skill and upon progress of scientific knowledge; it is a development "in depth," rather than "in breadth." The latter is the characteristic feature of the new country which is still able to apply the achievements of the older countries to the utilization of undeveloped wealth.

"How rapid and how original this development is, depends in the first place upon the character of the people. It is above all a question of self-estimation and enterprise. No nation has these virtues in a higher degree than the people of the United States. Its spirit of enterprise is the natural inheritance of their ancestors who, whatever might have driven them from their old homes, had the courage to build up new homes in a foreign country under strange and uncertain conditions. The self-estimation, however, of the individual man, as well as of the nation, is perhaps the most essential trait of the American character. It manifests itself in various forms: in the early independence of the youth; in the national sensitiveness which we often observe with surprise in the common people, as reflected in the daily press; in the opposition of any individual to official guardianship; in the ambition of the nation which wants to rid itself of its intellectual dependence on other countries. In my intercourse with widely-differing individualities among American chemists, nothing appeared to me so remarkable as their common tendency to prove and to have recognized the equal and independent standing of the industrial accomplishments of the United States as compared with the older successes of Europe. To recognize the value of these national virtues, it is sufficient to look at the neighboring country, Canada. On both sides of the political frontier there is a similar richness of treasures of nature, but the character of the nation which utilizes them with creditable alertness under the stars and stripes is missing beyond the frontier, and there is a great difference between the states of the industrial development in the two countries."

The enormous development of civil, mechanical and electrical engineering in the United States has been due to the dimensions of the natural conditions and to the lack of manual labor; the problems set by the conditions of the country, such as the distances to be overcome, etc., were so much greater in the United States than in Europe, that these branches of engineering have long ago become independent of Europe, and have undergone a development which in some respects sets an example to Europe. It is different in chemistry. In a young country, rich with metals as the United States is, the industrial development first requires only a relatively small knowledge

of chemistry, as absolutely necessary for metallurgical enterprise. Dr. Haber remarks that among American chemists the faculty of speaking or understanding German is nearly universal, but is very restricted among mechanical and electrical engineers. He considers this as a symptom showing the influence of Germany upon the development of chemistry in the United States.

He points out, however, that the period of the general influence of Germany on the chemical industrial development in the United States is now about passed. While he thinks that in organic chemistry Germany will retain the lead in the world, all the branches of inorganic chemistry in the United States have become or are becoming independent. Metallurgy has long become independent, and in the size of plants, the development of machinery and the output of metals, it has generally surpassed Europe. "In the inorganic chemical industries there is felt the coming of a new era. The deplorable, old, imperfect installations in this branch which a stranger sees with surprise in a country provided with the most conspicuous modern installations in metallurgy, and mechanical and electrical engineering, are quickly changed or are replaced by new installations." This change is indicated economically by a decrease of the prices of the products of inorganic chemistry which is always accompanied by an increase in output and sale.

Abstracts are given of statistical tables, prepared by Dr. Munroe for the last census of the United States, and attention is called to the fact that 1,740 chemical firms (with more than 2,280 plants) in the United States employ only 276 chemists. Of course this is not the total number of chemists in the United States. This number does not comprise the numerous chemists in the metallurgical plants, nor the independent consulting chemists, nor the pharmaceutical chemists, nor the professors of chemistry at universities. But the above figures show how different the Americans and the Germans look at the operation of a chemical plant. In the United States the chemical plant is a fully developed mechanism, the operations being carried out with mechanical regularity, although perhaps under a certain control by analysis; the American manufacturer does not consider research work as a necessary supplement to the regular operation of his plant, while the German manufacturer generally employs a certain number of chemists who do research work, the results of which are not felt by immediate improvement of the income of the factory, but only by possible results, hoped for in the future.

Dr. Haber then discusses at length the study of electrochemistry and of physical chemistry in American universities. A general comparison of American and German universities is given, and as instances of the study of chemistry on American universities some statistical notes are given on Harvard University, Leland Stanford, Jr., University, and the Case School of Applied Science, in Cleveland.

He finds that a characteristic difference exists between the requirements for entering a university in Germany and one in the United States. He says that the student entering a university in the United States has had by far less scientific education than in Germany. On the other hand in American boys a certain technical intuitive power is developed to a remarkable and much greater degree than in German boys; in this respect the workshops in high schools, manual training schools and universities, have an important influence.

In summing up his comparison of American and German universities Dr. Haber draws the following conclusion: From the German point of view, the education in chemistry in American universities appears "superficial and practical;" it is called superficial in view of the great number of students whose education ends with the degree of bachelor. The remedy against superficiality is the growing recognition of the importance of post-graduate work. From the American point of view, the education in chemistry in German universities appears "thorough and impractical." It is impractical because

the intimate connection between German universities and the industrial development of inorganic chemistry has been lost. Dr. Haber emphasizes the importance of physical chemistry to the inorganic chemist; physical chemistry is not a special branch of chemistry, but represents the only general method by which the chemist should think.

Dr. Haber then sketches the industrial development of electrochemistry in the United States. After some general statistical remarks he describes his route in his trip through the States: New York, Philadelphia, Niagara Falls, Sault Ste. Marie, Anaconda, Trail, B. C., Seattle, San Francisco, Denver, Chicago, New England States, Penn Yan, N. Y., New York, Kanawha Falls, W. Va., Baltimore, Philadelphia.

Concerning the situation in California, Dr. Haber shows how the high price of coal has caused the enormous development of long-distance electric transmission. He also points out that the situation has been somewhat changed in recent years by the increased use of California oil as fuel. For extended electrochemical industries in California he believes the cost of electric-power to be still too high. Moreover the country is not yet "ripe" for electrochemical industries, although there are good prospects for electrolytic copper refining in the northern part of the State, and for the electrolytic winning of tin from scrap tin in the southern part; as the price of zinc is high, the precipitation of gold from cyanide solutions by means of the electric current also appears promising.

Dr. Haber then makes some remarks on the new Moebius process for gold refining, as it has been used in Denver, and on Swart's and Blake's separation of metals by electrostatic means. In then passing to a general discussion of the industries at Niagara Falls, he begins with some critical remarks on water-powers.

The rapid development of some electrochemical industries, especially of the manufacture of aluminium, has been intimately connected with the development of water-power. But it would be wrong to generalize this statement by assuming that the enormous development of industries and engineering in general in the United States has been due to water-power developments. The increase of steam-power has been much greater since 1870 than the development of water-power. Dr. Haber characterizes the United States as the country of cheap coal. Since the last three years, the United States leads the world in the production of coal. Of 780,000,000 metric tons mined 1901 in the world, 33.9 per cent. were mined in the United States, 28.3 in England, and 19.5 in Germany. Besides the cheap price of coal, there are also low freight rates.

Concerning the cost of generating electrical energy by steam-power he makes the following remarks: "Very often the cost of the electric horse-power hour, produced by steam-power, is given at 1 to 1.25 cent." He emphasizes that this will be about right for a greatly varying load curve and discontinuous operation, but that for absolutely continuous operation with uniform load the cost is much smaller, and may be as low as 0.25 cent per horse-power hour. This latter figure is given as the cost of power generation by the Dow Chemical Co., in Midland, Mich. Dr. Haber points out that this plant is of peculiar interest, as it is an example of the electrolysis of a brine solution, in which only the anodic chlorine is utilized, while the cathode liquid, containing alkali mixed with salt, is wasted.

Canada is even richer than the United States in water-powers which can be cheaply developed. The reason why Niagara Falls has become the prominent centre of electrochemical industries, although the price for power is not very low, is that it is very favorably situated for shipping freight to different parts of the country. For similar reasons Sault Ste. Marie is important, although he believes that the power available at this place is not sufficient to expect a second electrochemical center there like Niagara Falls.

Dr. Haber then gives data concerning the amount of power

used by the different electrochemical concerns in Niagara. He thinks that for the power used in the two plants of the Pittsburg Reduction Co., 15,500 horse-power is nearer the truth than 10,500 as given by Dr. J. W. Richards; the company itself decline to give the exact figure. Dr. Haber then gives descriptions of the processes used by the Union Carbide Co., and the Pittsburg Reduction Co. at Niagara; the manufacture of ferrochromium by the Wilson Aluminium Co., in Kanawha Falls, W. Va., the manufacture of silicon copper by the Cowles Electric Smelting and Aluminium Co. in Lockport; and the Acker process in operation at Niagara. The success of the Acker process is said to be technically perhaps the most unexpected; the voltage is higher than in other process, but the current efficiency is better than in any other known process for alkali and chlorine. "The durability of the apparatus is said to be fully satisfactory, but it cannot be denied that in this important point absolutely sufficient data are not yet available. Assuming that the durability will be found to be satisfactory in the future, the process would have all chances of becoming the standard process on account of its simplicity and elegance, if there was not the high power consumption. In any case the success of the Acker Bros., who, in a work of eight years succeeded in passing from laboratory experiments over to a plant of 45 furnaces, consuming 3,000 electric horse-power in continuous undisturbed operation, is to be considered as a remarkable technical achievement."

A summary of the balance of Dr. Haber's lectures will be given in our next issue.

ELECTROCHEMICAL ANALYSIS.

BY IVAR IUEL MOLTKEHANSEN.

It is sometimes found in books treating with the subject of analysis by electrolysis, that the quantities of acid, etc., required for the analysis or for the separation of metallic compounds are given in percentages of this acid. On figuring out these data one finds, however, that these percentages do not refer to the concentrated substances. Still, one looks in vain for any statement elsewhere in the same book or essay as to the concentration of the said reagents, as a general statement is not to be found, and sometimes apparently solutions of varying concentrations of the same compound are referred to on different pages of the same book. This defect is even to be found in the classical research by LUCKOW, treating with the determination of lead as PbO_2 at the anode (*Zeit. f. Anal. Chemie*, Vol. 19, page 1). But as in electrochemical analysis it is of the highest importance that the concentration of the electrolyte be known, the difficulties arising from these omissions require investigation.

To illustrate, I met with these inaccuracies, as I sometime ago took up the problem of separating lead and manganese by electrolysis according to NEUMANN. The electrolyte he used was said to contain about 20 per cent. HNO_3 , but the concentration of this nitric acid is not mentioned (*Zeit. f. Elektrochemie*, 1895, Vol. 2, page 253; *Chem. Ztg.*, 1896, Vol. 20, page 383). On examination it was found, that NEUMANN in this case does not refer to percentages HNO_3 , but then to an acid of which concentration? Further NEUMANN only claims that this method gave him "approximately correct results."

It seemed for these reasons desirable to test his statements more closely by first finding out the quantity of acid necessary for the separation, and secondly testing the accuracy of the method. The principle of the separation of lead and manganese is to keep the manganese in the solution as permanganic acid and to precipitate the lead alone at the anode as lead peroxide. This is obtained by using a high current density and high concentration of acid and by heating the electrolyte. I succeeded in carrying through the exact separation of lead and manganese by greatly increasing the amount of acid in the solution. It was not found that the PbO_2 was more firmly deposited on the anode, if the electrolyte was heated to

70° C. (178° F.), before the current was turned on, and on starting the precipitation the Bunsen burner was taken away. The temperature would then slowly go down in thirty-five to forty minutes from 60 to 65° C. A separation is not possible when equal quantities of lead and manganese are contained in the electrolyte. According to my researches in this direction, it was found that the proportion at the lowest must be as 2 Pb to 1 Mn, but it is preferable to have a still greater excess of lead: 3 to 7 Pb to 1 Mn; 150 cc solution should not contain above 0.03 g. Mn. I could still analyze a solution with 0.04 gr Mn by adding a few cc oxalic acid at the critical moment, as shown by my analysis published in the *Chem. Zeitung*, Vol. 25, page 37. This method will be of importance for the analysis of many galenas containing small quantities of manganese.

The following conditions have proved favorable for carrying out the separation of lead and manganese according to my researches:

First. When the solution does not contain over 0.03 gr. Mn, the analysis should be started at 70° C. and 2 ampères for an anode area of 150 square centimeters the electrolyte should contain 25 to 27 cc nitric acid (1.42) in 150 cc, the total volume of the electrolyte, or 55 to 60 cc of the acid 1.19, corresponding to 18 per cent. pure HNO_3 . The electrolysis is completed in thirty-five to forty minutes, and it is of importance that the current should not be allowed to flow unnecessarily long.

Second. If there is more manganese (up to 0.04 gr to 150 cc) in the solution, satisfactory results are obtained by increasing the amount of nitric acid (1.42) to 35 cc by 2 to 2.5 ampères, but it is preferable in this case to use 25 to 27 cc HNO_3 (1.42) and add a few cc oxalic acid as soon as flakes of manganese hydroxide form in the electrolyte in order to bring these into solution again.

The red color of the solution is taken away by adding the oxalic acid, and it is necessary not to break the current until the strong red color is again perfectly regenerated. The whole analysis is finished in thirty-five to fifty minutes.

It is of importance to wash the anode very well with water before drying and weighing it.

I might further remark that the first method may be recommended for the regular determination of lead even without any impurities in the electrolyte, as I often found a slight precipitate of lead on the cathode, when according to the regular formula less nitric acid was added to the electrolyte. As a further advantage of my method may be considered that the entire analysis is brought to an end in forty-five to fifty minutes, instead of the seventy to seventy-five minutes required for the analysis at a lower current density in a weaker acid solution.

CONDITIONS OF PROGRESS IN ELECTROCHEMISTRY.

In the following we abstract the conclusion of Dr. J. W. Richards' presidential address to the American Electrochemical Society the first part of which was given on pages 324 and 325 of our May issue:

IV. INCREASING APPLICATION TO INDUSTRIAL NEEDS.

"In order not to become a mere code of observed and classified facts, a thing to interest men by its intrinsic perfection, but no other earthly use, a science must find practical applications which increase the comfort, pleasure or wealth of mankind. In this field electrochemistry is in no manner lacking; it abounds in notable achievements. If that man is a benefactor of the race who, figuratively, makes two blades of grass grow where but one grew before, then the practical electrochemist certainly takes high rank among the benefactors of mankind. The whole circle of human industry consists in utilizing the fleeting value of the perishable capacity to labor, linking it with natural forces, and thus turning into valuable products natural crude material. The items concerned are crude material, power, brains and industry. Power alone is

apt to be regarded as the first desideratum for the success of electrochemical processes, but knowledge, thinking power and industry are more primary factors. Given these, crude materials to work with will be found on every hand, and power sufficient will be created if it is not to be found."

The author discusses the problem of cheap power. He refers to the developed water power and to the still undeveloped surplus power from blast furnaces, obtainable by gas engines. There are scattered over the United States, in some of our most flourishing industrial centers, undeveloped powers which aggregate over 1,000,000 horse-power, which can be developed at no more cost than the average water-power, and can be generated just at the spots where they can be most favorably utilized.

This increasing development of power and its increasing application to industrial purposes is best promoted by the intimate and cordial co-operation of theoretical with practical electrochemists. This is attained by many agencies, but the most potent are research companies and our American Electrochemical Society.

V. AN INCREASING DISSEMINATION OF THE LITERATURE AND FACTS OF THE SCIENCE.

"No modern science can progress if it adopts the mediaeval practice of the alchemists, and carefully guards its wisdom for the exclusive use of the initiated. Widespread dissemination of the literature of our science, not only among our own fraternity, but amongst educated people in general, and even down to the rising generation of expectant scientists, is as necessary to our progress as is the recruiting of the human family to the preservation of the race."

The author discusses in detail and at length the influence which the transactions of technical societies, technical journals, monographs and text-books can have on the progress of the science and industry.

VI. AN INCREASING VISION OF THE POSSIBILITIES OF THE SCIENCE.

"If we ask the student of electrochemistry why he chooses this for his life work, he will possibly reply that he has been advised, by counsellors in whose judgment he relied, that this is a most promising field for his activities. More probably he will answer that, by reading himself some of the literature of electrochemistry, he became attracted by the novelty of what was being achieved, and wished to take part in a science with such a promising future. In either case the knowledge of what is and the vision of what may be in this almost virgin field of human endeavor is the magnet which draws recruits and adds to the working forces in our ranks."

"If we ask the enthusiastic worker in his laboratory what is the principal force keeping him at his work, which ever incites to fresh activity and lightens labors which might otherwise easily become tedious, the ready reply is that there is so much to do, so much to find out, so much promise of achieving great things, that he would be made of very dull stuff indeed who would not be enthused thereby. The ever-widening vision of an ever-widening field is the reward and the inspiration of every honest worker, and is the mainspring of the mechanism whose working means progress to our science."

"In every field of human endeavor, for the teacher in his class room, the writer at his table, the editor at his desk, the workman at his labor, the investigator at his task, the chief incentive to happy, productive work is the vision and the promise of what may be attained. Without that vision life would be dull indeed."

"To the seers of old was ascribed the wisdom of the ages, and, with the prophets, they guided humanity to higher and nobler things. The seers saw before them and before humanity the things which might be, the promise of the future, the possibilities for development which lay before the race. They gave new life and hope to mankind by proclaiming the possibilities which might be achieved."

"In like manner each one of us is inspired and encouraged,

nerved to high endeavor and imbued with the spirit to do and to achieve by the sight or vision of the possibilities of electrochemical science. Some may have the vision but dimly; others see clearly and far into the future which yet lies so close before us, but each is privileged to share in part the vision of his neighbor."

"If there is, therefore, one thing which an electrochemical society, such as ours, achieves of more superlative worth than any other thing, it is the resultant enlargement of vision which comes to each of its members, mainly and chiefly from the interchange of thought, the sharing of ideas, the communication of insights into the possibilities of the science resulting from our semi-annual meetings. Does not each one of us go away from these meetings feeling that he has been sharing in the

visions of all his electrochemical brethren, and with his mind so overloaded with suggestions, thoughts and ideas of what may, can and will be done in the near future that he wishes he had a dozen lifetimes at his command, in order to work out to realization this plentitude of ideas? Such is the zeal and ardor which our meetings engender in a high degree, resulting from listening to papers and discussions, by conversations, by simple handshakes and seeing our friends, and by breathing the invigorating atmosphere of our assemblies."

"Let us, then, you and I, one and all, see it as our privilege, as well as our duty, to promote in every way the interest, the attractiveness and the scientific atmosphere of these meetings, for they are, if we will but realize it, the elixir of life to the development of electrochemistry in America."

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By GEORGE P. SCHOLL.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Electric Furnace. E. A. Sjoestedt, Sault Ste. Marie, Canada. Assignor to the Lake Superior Power Co. Patent 726,364, April 20, 1903. Application filed September 20, 1901.

The specification describes an electric furnace for the smelting of ores, especially iron ores, and the object of the invention is said to be the construction of an electric furnace that will withstand for a reasonable time the great heat developed, have apertures for the escape of gases of combustion, for tap-

ping slag and metal and stoking holes for breaking up the slag crusts, etc. The furnace is shown in cross-section in Fig. 1. It consists of a cast iron body B, and a bottom frame C, with an interior refractory lining B^cC^c. The lower parts of the sides and ends and the bottom frame are constructed with water jackets b, c. The bottom is removable and the furnace body is raised considerably above the floor by legs F, in order to make it possible to run a ladle car under it, which travels on the rails g. H is the slag notch and I the tapping hole. The upper electrode K, consists of a battery of square carbon pencils, and is introduced through the cover D. The bottom electrode L is laid on the refractory lining C, and makes con-

tact with the base of the furnace, where the current is introduced, by means of the frame C. In starting the furnace when smelting iron ores the electrode K is brought so close to the bottom L, that an arc is struck. The powdered ore and flux are then fed in and it is said that a slag is soon formed, which acts as an electrode and thus protects the bottom carbon. As the ore is reduced, the metal sinks to the bottom and the electrode is gradually raised. The slag is drawn off and the metal tapped as required.

Electric Furnace. J. M. Carrere, New Brighton, N. Y. Patent 726,860, May 5, 1903. Application filed May 22, 1902.

This furnace is intended for the treatment of various materials, such as ores, cement, rocks, etc., for the reduction, melting, etc., by the current. It looks much like an ordinary rotary cement kiln and is similarly inclined at an angle, though it may be placed horizontally if desired. It has appliances for being rotated. The body of the furnace consists of an iron shell, which is by preference made in two parts and furnished with the necessary stiffening appliances. It is lined with graphite or other substances of low electric conductivity, and this lining is throughout insulated from the shell by an intervening layer of asbestos. The ends of this shell are closed by iron caps, which are likewise furnished with a layer of graphite insulated by asbestos. The ends of the shell extend between and pass into the caps. The cap ends are provided with contacts in such a manner, that the latter make electrical contact with the graphite lining of the cylindrical shell. By these contacts a current may be introduced, as the shell revolves, into the graphite lining, which can by this means be heated to any desired temperature. In addition, there are two carbon electrodes introduced into the cylinder, from opposite ends, passing through a bushing in the respective caps. The carbons are longitudinally movable in the bushings, and by this means the arc produced between them may be established and adjusted to any desired point within the cylinder, and consequently a maximum of heat established at that particular point. It is claimed that by this arrangement, the time in which the materials to be treated are brought into contact with the heated surface may be precisely regulated, and that the heat produced in the furnace may be either uniformly distributed over the surface of the lining or may be concentrated at a given point, or the surface of the graphite lining may be uniformly heated, and at the same time an intense heat generated centrally at a given point within the cylinder. The upper end of the cylinder receives the charged materials, while the treated matter is discharged at the other end. Either alternating or direct current may be used. The surface of the interior of the furnace is brought to incandescence by first establishing the arc and then drawing it the length of the

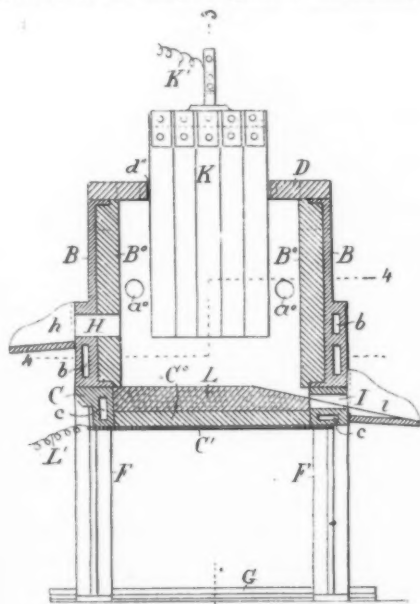


FIG. 1.—ELECTRIC FURNACE.

ping slag and metal and stoking holes for breaking up the slag crusts, etc. The furnace is shown in cross-section in Fig. 1. It consists of a cast iron body B, and a bottom frame C, with an interior refractory lining B^cC^c. The lower parts of the sides and ends and the bottom frame are constructed with water jackets b, c. The bottom is removable and the furnace body is raised considerably above the floor by legs F, in order to make it possible to run a ladle car under it, which travels on the rails g. H is the slag notch and I the tapping hole. The upper electrode K, consists of a battery of square carbon pencils, and is introduced through the cover D. The bottom electrode L is laid on the refractory lining C, and makes con-

cylinder, meanwhile having the independent current through the lining also available.

Method of Utilizing Calcium Carbide Refuse and Product Thereof. G. E. Cox, Niagara Falls. Assignor to Union Carbide Co. Patent 727,095, May 5, 1903. Application filed September 3, 1902.

The inventor claims to have discovered a method for fusing the calcium carbide refuse and converting it again into the commercial product. This refuse is largely carbide dust from the breaking up of the large blocks, mixed with partly or wholly unreduced material. This material cannot be used in the acetylene generators, as it floats as dust on the surface of the water until enough has accumulated to cause it to sink, and then a very rapid evolution of acetylene takes place which might injure the generator. If an attempt be made to fuse this refuse in the ordinary carbide furnace, it is soon found that it will not work, owing to the high conductivity of the material, which causes the electrodes to become short-circuited and destroyed. The heat generated is not distributed properly in the furnace, but the electrodes and connections become unduly heated. Other methods for utilizing this refuse were also not successful. The method applied in the present instance consists in treating the refuse in a suitable electric furnace, that is to say in one, in which the electrodes are separated much farther than they are in the ordinary carbide furnaces, using coke and lime. Electrodes of graphite are used in preference to ordinary carbon electrodes. It is stated that the conductivity of the electrodes and the charge of refuse is so great, that it is necessary to use a much lower voltage than in the ordinary carbide furnace. For example, a furnace for refuse using the same electrical energy as a furnace fed with lime and coke may be operated at one-half the usual voltage and with double the amperage, this ratio however being variable and dependent upon various conditions. Thus a furnace, which is built for refuse is quite unsuited to a charge of coke and lime, while under the conditions mentioned, it works quietly and the refuse fed into it forms a solid ingot of carbide, which is broken and packed as usual. It is stated that the heat generated by the passage of the electric current through the furnace and which serves to raise the charge to a temperature at which it will melt into an ingot, may be due either to the resistance of the refuse or to arcs sprung between the ends of the electrodes and the refuse, or to both.

APPARATUS AND PROCESSES FOR THE ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Electrolytic Manufacture of Chlorates and Perchlorates. Pierre Lederlin, Chedde, France. Patent 727,813, May 12, 1903. Application filed July 11, 1902.

The inventor claims: "A method for the manufacture at a high constant yield of chlorates and perchlorates by electrolysis of a chloride solution, with the previous addition of a corresponding neutral chromate, consisting in maintaining the electrolyte during the electrolysis in a non-alkaline state by the addition of hydrochloric acid." The approximate proportions of the neutral chromate and the saline electrolyte (chloride solution) is stated to be 2 grams of neutral chromate to 20 grams of the saline electrolyte. In this manner, the inventor states, he causes, owing to the acidity, the favorable property of chromic acid to entirely and continually compensate the cathodic reduction, which is one of the causes for the loss of yield. A yield of 0.55 to 0.50 grams per ampère hour is claimed to be obtained with NaCl, corresponding to 84 per cent. of the theoretical yield.

Art of Producing Hydroxylamine. Julius Tafel, Würzburg, Germany. Patent 727,025, May 5, 1903. Application filed February 24, 1902.

The object of this invention is to produce hydroxylamine by electrolytic reduction. The inventor claims to have discovered, that hydroxylamine may be obtained in good quantities

by electrolysis under suitable conditions of a solution, containing an acid electrolyte in addition to the nitric acid to be reduced, it being therefore possible to produce hydroxylamine directly from nitric acid on a commercial scale. It is necessary to carry out the reduction while well cooling, and care must be taken to stir the electrolyte quickly and uniformly. The possibilities of an excess of nitric acid must also be avoided. The nitric acid is therefore added slowly in the proportion in which it is being used, so that it is supplied only at one concentration, just sufficient for the most advantageous employment of the current. As cathode material mercury or an amalgamated cathode are specially suitable, although the reduction may also be carried out by the employment of a cathode of lead, tin, silver, nickel, bismuth or copper. Other by-products of the reduction of nitric acid are produced in more or less subordinate quantities, according to the material of the cathode used. The methods of procedure are described as follows:

(1.) Reduction of nitric acid to hydroxylamine in sulphuric acid solution. An electrolytic cell is separated into an anode chamber and a cathode chamber by a diaphragm. The cathode chamber is filled with 6 kilograms of 50 per cent. sulphuric acid, the anode space with the same 50 per cent. sulphuric acid. Each chamber of the cell is provided with means for cooling. The cathode consists of well-amalgamated lead, while the anode is formed of pure lead. A current of 60 to 120 ampères per square decimeter is now sent through the bath, both spaces of the cell being well cooled. Thereupon 2 kilograms of a 50 per cent. solution of nitric acid are added slowly to the bath by a dropping apparatus, so that always a slight evolution of hydrogen is just noticeable at the cathode. At the same time the cathode solution is powerfully stirred. During the operation it is advisable to keep the temperature of the bath at about 20° C. The reduction is carried out until a test of the cathode liquid proves there is no further nitric acid in it. The resulting hydroxylamine is then isolated from the reaction liquid as chlorhydrate or sulphate.

(2.) Reduction of nitric acid to hydroxylamine in hydrochloric acid solution. In carrying out this process, the same steps are employed as in the above, with the exception, however, that the cathode chamber is provided with 6 kilograms of about 20 per cent. solution of hydrochloric acid. It is preferable to employ a tin cathode or equivalent cathode, or if a cathode of indifferent material is used, then some spongy tin should be added to the bath in the proportion of about 10 grams per liter.

Manufacture of Camphidon. Julius Tafel, Würzburg, Germany. Patent 727,024, May 5, 1903. Application filed April 3, 1902.

Camphidin and Method of Preparing Same. Julius Tafel, Würzburg, Germany. Patent 727,026, May 5, 1903. Application filed August 13, 1902.

The two inventions relate to the manufacture of derivatives of camphoric acid, and more particularly to the preparation of products richer in hydrogen than imido-camphoric acid. The inventor states that he has found, that by subjecting imido-camphoric acid, which has the formula $C_{10}H_{15}NO_8$, to electrolytic reduction, a new body poorer in oxygen and richer in hydrogen is obtained, which new body he calls "camphidon." The reaction proceeds in a manner similar to that involved in the production of pyrrolidin from succinimide. If the reduction in the latter case is continued somewhat further, some pyrrolidin is concurrently obtained. In a similar manner a higher hydrated body, which is called by the inventor "camphidin," is formed together with the camphidon if the reduction is carried further. The two compounds are to be used for pharmaceutical purposes and are prepared in the following manner: 1 kilogram of imido-camphoric acid is dissolved in sufficient sulphuric acid of 65 per cent. strength to make 10 liters of solution, which is then poured into the cathode com-

partment of an electrolytic cell or bath. The anode compartment having been similarly charged with dilute sulphuric acid, the current is passed through the cell for three and a half hours, the current having a concentration or strength of 120 ampères per liter of the electrolyte, and the cathode surface being 10 square centimeter per liter of electrolytic bath. The cathode employed by the inventor is a lead cathode prepared by him according to the method given by him in the *Berichte der Deutschen Chemischen Gesellschaft*, Vol. 33, page 2,209. After the reduction has been completed, the major part of the sulphuric acid is removed by precipitation with calcium carbonate, filtering and extracting the resultant camphidon from the filtrate by repeatedly shaking with chloroform. Upon thereafter evaporating the chloroform, the camphidon is left as a soft crystalline mass, having a weak or faint camphor-like odor. From the acid filtrate, from which the camphidon has been removed, in the manner indicated above, the new compound camphidin is obtained by first supersaturating with an alkali, such as soda lye and then driving off the camphidin with steam. It is thus obtained as a light, soft, crystalline mass, having an intense camphor-like odor. Its composition is indicated by the formula $C_{10}H_{10}N$. At 180° centigrade it melts to form a colorless liquid, which distils without decomposition at 200° centigrade. It is soluble with considerable difficulty in cold and hot water. It is distinguished from camphidon by its volatility under the influence of steam or aqueous vapor and by its strong basicity. The above methods are interesting examples of the use of the reducing effect of the current.

Production of Permanganates. Wilhelm Hickmann, Frankfurt-on-the-Main. Assignor to Society Chemische Fabrik Griesheim, Electron. Patent 727,792, May 12, 1903. Application filed March 3, 1903.

This invention covers a method for the obtaining of such permanganates, such as calcium permanganate, which are not readily obtained by the metathesis of suitable salts and alkali permanganates. It has been found that these reactions, which cannot be obtained in a purely chemical manner, take place, when mixtures of solutions of alkali permanganates or permanganates are, together with the oxygenated or halogen compounds of the metals of which it is desired to obtain the permanganates, subjected in a suitable manner to the action of the current. The preparation of calcium permanganate is carried out as follows: (1) An electrolytic cell is employed, the anode compartment of which is separated from the cathode compartment by a diaphragm or other suitable means, so that the anode liquid is prevented from mixing with the cathode liquid and a reduction of the permanganate is avoided. Both compartments are closed at the top and provided with outlet pipes through which the gases escape separately. The cathode compartment is filled with diluted potash lye and the anode compartment with a saturated solution of potassium permanganate, which is maintained in the state of saturation by means of sieves suspended in the liquid, which are filled with potassium permanganate. Washed calcium hydroxide is introduced into the anode compartment, this being preferably done gradually, as the operation is proceeding, so as to prevent the diaphragm being stopped. If now a current is passed through the cell, the potassium ions migrate into the cathode compartment, where caustic potash is formed in the usual manner and hydrogen given off. The MnO_2 ions remain in the anode compartment, and from these oxygen is evolved, while at the same time permanganic acid is formed, which, as soon as it forms, combines with the calcium hydroxide held in suspension, thus forming calcium permanganate. When the calcium salt has reached a certain concentration, it is advisable to interrupt the electrolysis and to separate by crystallization the potassium permanganate that is still remaining in the anode liquid.

(2.) When calcium chloride is used instead of calcium hydroxide, the cathode compartment of the apparatus is filled with a saturated solution of potassium chloride. The anode

compartment contains a saturated solution of about 100 kilograms of potassium permanganate, to which are added 20 kilograms of calcium chloride. Sieves containing potassium permanganate are arranged in the anode compartment in the usual manner. Under the influence of a current, of 2 or 3 ampères per square decimeter of electrode, Cl is yet free at the anode, while the K ions travel into the cathode compartment. It is stated that the corresponding quantities of Ca (or $CaCl_2$), and MnO_2 ions remain in the anode compartment and combine together to form calcium permanganate. The influence of the OH ions, which migrate in a smaller number into the anode compartment and might give rise to an intermediate formation of hypochlorous acid or chloric acid, need not be taken into account, as these substances are said not to be very stable under these circumstances. The electrolysis might be continued until the cathode compartment contains a quantity of potash lye corresponding to the amount of calcium chloride used, but it is preferred to stop the operation before this stage is reached. The yield in calcium permanganate is stated to correspond to the amount of caustic potash obtained. The calcium permanganate is obtained from the anode liquid by fractional crystallization.

STORAGE BATTERIES.

Storage Battery. R. N. Chamberlain, Depew, N. Y. Patent No. 725,218, April 14, 1903. Application filed August 13, 1902.

The object of the invention is to provide a covered tank, jar or receptacle of simple and inexpensive construction which will effectually prevent the wasting of the electrolyte by evaporation; will return the escaping moisture to the electrolyte; will prevent the formation on the cover of an acid conductor across the battery plates or cells, and will afford easy access to the cell for the purpose of taking hydrometer and temperature readings. Claim No. 1 reads: "The combination with a tank or receptacle provided with a bottom, side walls and end walls, which extend upwardly above the tops of the sides walls, of battery plates arranged in said receptacle and provided with necks which project laterally over said side walls, and a cover for said receptacle, which is supported by said end walls."

Secondary Battery Electrode. J. Hahmann, Berlin, Germany. Patent No. 724,856, April 7, 1903. Application filed July 19, 1902.

The accompanying Fig. 2 shows the electrode proposed by

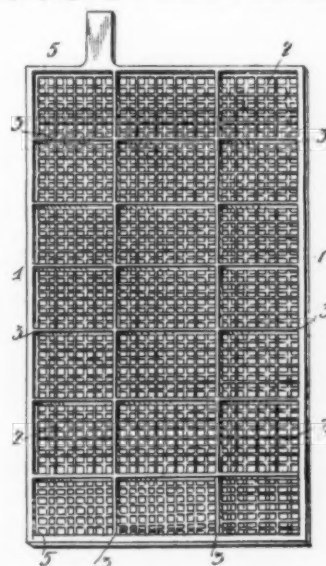


FIG. 2.—STORAGE BATTERY PLATE.

the inventor. It is composed of an oblong frame 1, which is

molded in box shape, with open top and a reticulated bottom surface 2. This bottom surface is very thin, and is stiffened by intermediate bars 3, which divide the plate into compartments. The cross bars 3 are flush with the border of the frame. Into the basin-shaped inclosure, formed by this frame and the reticulated bottom, the active material is packed and retained therein by a reticulated cover plate, which fits on the base frame and is soldered to it. The base plate, with its reticulated bottom and cross bars, and the reticulated thin cover plate are cast of an alloy of lead and antimony.

Electric Accumulator. A. Schmidt, Predari, Weimar, Germany. Patent No. 724,619, April 7, 1903. Application filed July 24, 1902.

The invention consists in providing special active masses for the negative and positive electrodes. The active mass for the negative electrodes is composed of a mixture of lead oxide, red lead, calcium hydroxide and alkali trisulphate; two parts of lead oxide, one part of red lead, one-twentieth part of calcium hydroxide and one-twentieth part of sodium thiosulphate having been found to give good results. The active mass for the positive plate is made of one part lead oxide, two parts of red lead and about one-twentieth part of spongy lead. This latter is preferably prepared by immersing several plates of lead in a solution of sodium thiosulphate of 1.07 to 1.12 specific gravity and passing an electric current. The active masses thus obtained are kneaded to a magma with dilute sulphuric acid, and then applied to the plates in the usual manner. The plates are preferably formed in a solution of glauber salt, of a specific gravity of 1.09 at a temperature of 25° to 30° C. The formation takes from two to three hours, and the formed plates may be used with the usual electrolytes; but the electrolyte best fitted for them is sulphuric acid to which an alkaline thiosulphate has been added. Sulphuric acid of 1.14 specific gravity, with an addition of sodium thiosulphate solution of 1.04 specific gravity, has been found suitable, the proportions being, preferably, two volumes of sulphuric acid and from one-half to one volume of sodium thiosulphate solution. This liquid, which is at first turbid, becomes clear when the accumulator is first charged and then remains clear.

MISCELLANEOUS.

Electro-endosmotic Process of Extracting Sugar. Botho Schwerin, Berlin, Germany. Patent No. 723,028, March 31, 1903. Application filed November 15, 1901.

The invention relates to the process of extracting sugar by acting with the electric current upon disintegrated wet saccharine material which is placed between a negative elec-

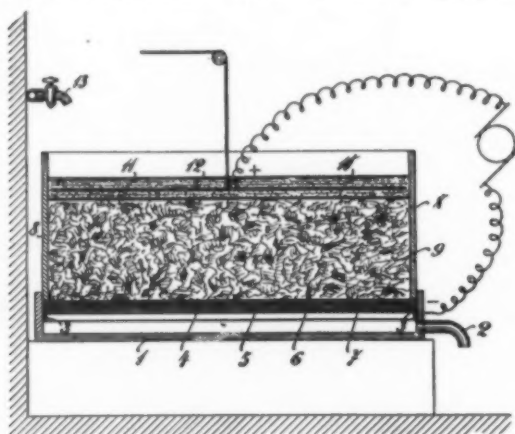


FIG. 3.—ELECTRO-ENDOSMOTIC TREATMENT OF SUGAR.

trode pervious to liquid and a layer of water separating the positive electrode from the saccharine material. The apparatus used for carrying out the process is shown in Fig. 3. A

wooden box 1 of square shape, open at the top, is provided at its bottom with an outflow 2 for the sugar solution. Near the upper edge of the box are fixed at the inside supports 3 for a layer of wire gauze 4 and a layer of carbon 6, which is held between filter cloths 5 and 7. When the wire gauze and the carbon layer are placed, a frame 8, preferably constructed of wood, is inserted, closely fitting into box 1, so as to firmly clamp the wire gauze, filtering cloths and carbon layer between its lower edge and the supports 3. The frame is then filled with the saccharine material 9 up to a certain distance from its upper edge; the material is covered with a filtering cloth 10 and a mixture of water 11, and an earthy compound or compounds—for instance, calcium carbonate or magnesium oxide—is poured on top of it. A metal plate 12, serving as anode, is then suspended in the water. The wire gauze 4 serves as cathode. It is claimed that by causing the liquor to pass through a layer of finely-divided carbon, preferably animal charcoal, the albuminous matters dissolved in the liquor are caused to separate out upon the surface of the carbon layer, and that directly a concentrated, pure and almost colorless solution fit for crystallization is obtained without the necessity of special costly apparatus. Another improvement is claimed to result from suspending finely-powdered earthy compounds into the water surrounding the anode. These oxides or carbonates are stated to react with the acids that appear at the positive electrode to form salts, which, for the greater part, are insoluble in water. The anode is thus protected against decomposition, and the water is prevented from being infected with substances which might diffuse back into the saccharine material, with the result of producing invert sugar or otherwise impurifying the sugar solution.

CURRENT NOTES.

UNIVERSITY OF WISCONSIN.—We have received Bulletin 67 of the University of Wisconsin, which contains very neat illustrations of the buildings and surroundings of the University.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The annual business meeting of the American Institute of Electrical Engineers was held on May 10th in New York City. As the result of the annual election Mr. Bion J. Arnold was declared president. The summer convention of the Institute will be held at Niagara Falls in July.

AMERICAN ELECTROCHEMICAL SOCIETY.—At the meeting of the Board of Directors, held at Philadelphia on May 9th, the following gentlemen were elected members of the Society: J. J. Kennedy, New York; M. Temple Taylor, Savannah, Ga.; Archibald Meldrum, Savannah, Ga.; Charles D. Chastaney, New York; Howard W. DuBois, Philadelphia, Pa.; Joseph P. Devine, Buffalo, N. Y.; J. S. Crider, Cleveland, Ohio; Herman Poole, New York; C. E. Doolittle, Aspen, Colo.; S. Lawrence Bigelow, Ann Arbor, Mich.; Charles B. Dudley, Altoona, Pa.; Emanuel Stein, New York; William L. Nadolsky, New York; E. H. Whitlock, Cleveland, Ohio; Arthur Benjamin Frenzel, Denver, Colo.; F. Warren Smith, Los Catos, Cal.; E. A. C. Smith, Baltimore, Md.; Hans A. Frasch, New York.

CORNELL UNIVERSITY.—We have received the Register of Cornell University for 1902-3. It contains notes on its foundation and endowment, a list of the board of trustees, the departments and faculties, the officers of the University, information on admission and classification, residence and graduation, scholarships and prizes, the graduate department, the academic department, the college of law, the medical college, the New York State veterinary college, the college of agriculture, the New York State college of forestry, the college of architecture, the college of civil engineering, the Sibley college, the University library, the Sage chapel and Barnes hall, the Cornell infirmary, a list of fellows and scholars and a catalogue of students. The total number of regular students is 2,968.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

By CARL HERING.

INDUSTRIAL ELECTROCHEMISTRY.

Production of Zinc.—Getting zinc from its ores, particularly from poor ores, is a very tempting process for electrochemists, as the field would be a large one, but the difficulties seem to be in proportion, and so far the success does not seem to have

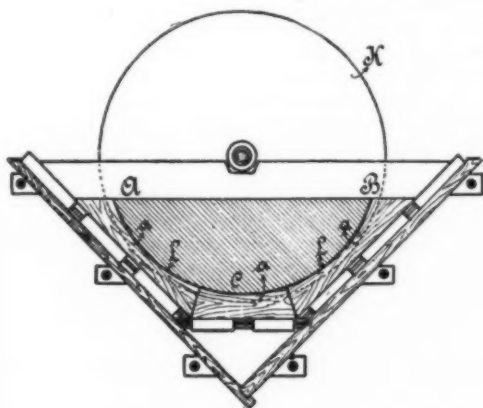


FIG. 1.—HOEPFNER CELL.

been very great. One of the inherent difficulties is that the combination heat of zinc compounds is generally rather high, thus necessitating the expenditure of a relatively high power; and for the same reason other metals are apt to deposit first, thus necessitating a pure solution. The late Hoepfner devised a process which was in use in Fuhrfort, Germany, from 1895

raw material was the cinder from zinciferous pyrite, mined in Westphalia, the zinc tenor of this cinder varying from 10 to 16 per cent. The preparatory treatment consisted in grinding the cinder to 1.5 mm size, mixing with 18 to 20 per cent. of common salt, and roasting in a muffle furnace for twenty to twenty-two hours at a temperature of not over 650° C. The charge of the cinder per furnace was 4,500 kg and the coal consumption 900 kg per charge. The charge drawn from the furnace was leached, while still hot, in iron vats with water or dilute liquor from a subsequent stage, affording a solution containing about 10 per cent. of zinc, besides sodium chloride, sodium sulphate, and small quantities of lead, copper, cadmium, arsenic, manganese and thallium. The sodium sulphate was crystallized out as $\text{Na}_2\text{SO}_4 + 10\text{H}_2\text{O}$ by cooling the solution to -5° C, after which iron and manganese were precipitated by the addition of bleaching powder and marble dust, and finally the electronegative metals by means of zinc dust. A clear solution of the chlorides of zinc and sodium was thus obtained, which on the average assayed 20 per cent. Zn Cl_2 , 22 per cent. Na Cl , 0.05 to 0.06 per cent. H_2SO_4 , and traces of lead, iron and thallium, and after acidification with a small amount of hydrochloric acid, free from arsenic, was ready for the electrolysis. The electrolytic vats were V-shaped tubs; the anode and cathode compartments were separated from each other by means of a diaphragm of nitrated cloth. The arrangement of the vats is shown in the two adjoining figures, of which Fig. 1 is a transverse section of the electrolytic vat through the cathode cell, and Fig. 2 a plan; a is the cathode, b an iron sleeve to secure it to the shaft c, d the anode, and e, f, g, h the mechanism for revolving the cathodes, while i and k are conductors for the current. Artificial carbons, hard as glass, were used as anodes, while the

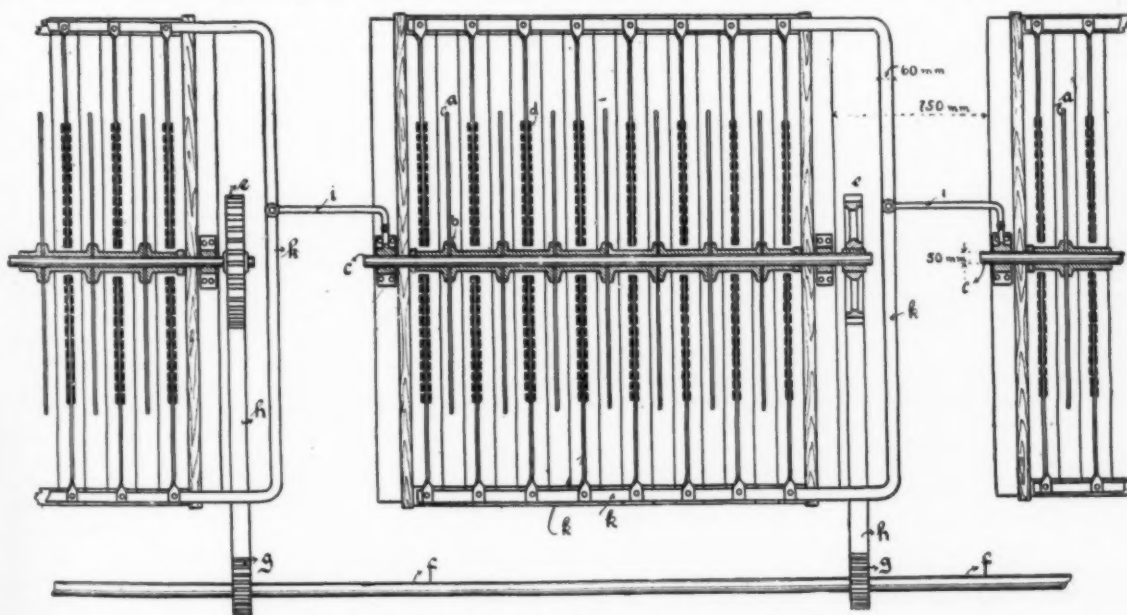


FIG. 2.—ARRANGEMENT OF CELLS IN THE HOEPFNER ZINC PROCESS.

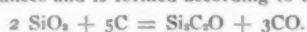
to 1897, but was discontinued, although, it is claimed, this was for personal and not for technical reasons. GUENTHER, in the *Eng. and Min. Jour.*, May 16th, gives a long illustrated description of this process, which is briefly as follows: The

cathodes consisted of discs of zinc or iron, arranged vertically on the horizontal shaft so as to revolve between a pair of adjacent anode cells. Each vat had 8 anode and 7 cathode departments. The electrolyte enters each vat on one of the

horizontal sides, and comes out at the top of the opposite side, so there is only a circulation past the cathodes, but the solution can pass beneath the anode cells; the diaphragms which are closed on top, where they are made air-tight by means of melted pitch, prevent a rapid motion in the anode cells. The solution entering the vats had a tenor of 9.5 to 10 per cent. Zn, and the tenor of Zn in both should not be less than 2 per cent. The acidity to be maintained at 0.08 to 0.12 per cent. HCl, and during the electrolysis acid was added to the extent of 0.03 to 0.05 gram HCl per ampère hour. A good deposit of zinc could not be obtained from neutral or alkaline solutions. The vats were connected in series and a current density of 100 ampères per square meter used, which, the author believes, was less than desirable; the terminal voltage of the bath was 3.3 to 3.6 volts; in regular operation zinc would deposit on the cathodes in dense form, silver white in color, and the current efficiency was 97 per cent. or more of the theoretical. After thirty to thirty-five days, when 800 to 1,000 kg of Zn had been deposited, the cathodes were replaced by a new set. The zinc was then remelted in a reverberatory furnace, losing 1.5 to 2 per cent. in weight, "wherein the consumption of coal was 7 to 8 per cent.;" the final product assayed 99.97 to 99.98 per cent. Zn, 0.01 to 0.02 per cent. Pb, and traces of iron and thallium. The anode cells had an outlet pipe of glass or hard rubber; the chlorine gas liberated by electrolysis was used for making bleaching powder. The author then gives an estimate prepared by him of the cost of plant and operation for producing 650 metric tons of spelter per year, and the corresponding quantity of bleaching powder. This estimate appears to be based on commercial conditions existing in Germany; he reaches the conclusion that the profit in the whole process will be \$13,500, as the return on an investment of \$162,500 in plant.

Electrogalvanizing.—It seems that the replacing of the hot process of galvanizing by the electrolytic process of zinc plating is at last beginning to be appreciated and is finding a field in the ship-building industry, where it is said to be used extensively with excellent results, provided the process is properly carried out. It seems, however, that sometimes the work may have a good appearance, but when tested it is found to be only colored or flashed with zinc, due to a bad connection or the bath being too acid, or the dynamo of too small a capacity for the size of the work under treatment. According to COWPER-COWLES, who has done so much pioneering work in this field, an electrogalvanizing plant, he says, should be so arranged as to be practically automatic in order that it can be placed in the hands of any intelligent workman. This, he claims, is accomplished by doing away with zinc anodes, substituting insoluble lead anodes for them and replenishing the zinc deposited from the electrolyte by passing it over filter beds containing zinc powder or dust. A plant of this kind, recently installed in London, is described by him in the *London Elec. Rev.* for April 24th.

Siloxicon.—This is the name given to a new compound recently patented by Acheson, as noticed in *ELECTROCHEMICAL INDUSTRY*. It is composed of silicon, carbon and oxygen, and promises to be very valuable in metallurgical apparatus as a refractory material. It seems to contain various oxygen compounds of carbon and silicon, whose formulas vary from $\text{Si}_2\text{C}_2\text{O}$ to $\text{Si}_2\text{C}_2\text{O}_2$. The former may be considered typical of the new substances and is formed according to the equation:



In the *Eng. and Min. Jour.*, May 16th, FITZGERALD describes this material, as also the furnace for making it. The material is of a gray-green color, has a density of about 2.75, is indigestible, infusible, neutral, insoluble in molten metals and unaffected by any acids, with the exception of hydrofluoric, which seems to act on it very gradually. Many experiments have been tried on siloxicon as a refractory material for lining furnaces, crucible manufacture, etc., and as far as these

experiments have gone, the substance promises to be a valuable addition to the industrial arts.

Formation of Insoluble Compounds.—ISENBURG gives a long account of experiments on the formation of insoluble (or difficultly soluble) compounds, especially white lead, by electrolysis with soluble anodes, by the method of Luckow. It is published in the *Zeit. f. Elektrochemie*, April 9th. The principle of this method is to use a mixture of two electrolytes and an anode of the required metal, one electrolyte having an anion the required acid radicle, the other electrolyte being another indifferent salt the acid radicle of which forms with the anode an easily soluble compound. An example of this method, studied by LeBlanc and Birdschedler, is the formation of lead chromate by using lead as anode and a mixture of potassium chromate and potassium chlorate as electrolyte. The authors found that when the concentration of the chromate ions is small, compared with the concentration of the chlorate ions, the formation of lead chromate goes on easily, and the anode remains bright lead. They gave the following explanation of this fact which appears at first sight difficult to understand; if an electrolyte of potassium chromate alone is used, lead chromate is formed immediately on the surface of the lead anode and the anode is thus covered with a firmly-adhering layer of lead chromate; the further formation of lead ions is thus made impossible and peroxide of lead is formed. If, however, a mixture of potassium chromate and chlorate is used with a surplus of the latter, then a layer of lead chlorate (which is soluble) is formed in the neighborhood of the electrode, and the formation of lead chromate occurs at some distance from the electrode, namely, at the points where the layer of lead chlorate is in contact with the potassium chromate; the lead chromate thus formed, cannot adhere to the anode which therefore remains bright, and the process thus goes on without difficulty. The present author has studied the analogous process for making white lead. He experimented with a 1.5 per cent solution of a mixture consisting of varying quantities of NaClO_3 and Na_2CO_3 , and found that in this case also the current efficiency is higher and the lead anode remains in better condition, the greater the amount of NaClO_3 compared with that of Na_2CO_3 . There is no formation of lead carbonate, if only Na_2CO_3 without NaClO_3 is used as electrolyte. Stirring may in this case have bad effects, as it brings the carbonate ions directly to the anode so that the formation of lead carbonate occurs directly on the surface of the electrode, instead of at some distance from it. In his experiments carbonic acid was supplied in such a way that small bubbles were rising slowly at the anode upwards. The current density was 0.5 ampères per square decimeter. It appears that the supply of carbonic acid must be kept very carefully within certain limits in order to obtain a pure compound $2\text{PbCO}_3, \text{Pb(OH)}_2$.

Ozone.—An illustrated article on the preparation of ozone by electricity is begun by KAUSCH in the *Elektrochem. Zeit.*, for April. The original apparatus of Werner Siemens and the modern arrangements of Siemens and Halske are described.

THEORETICAL AND EXPERIMENTAL.

Ions in Solution.—An article from the president of the Reichsanstalt. In the present one, which is published in the *Proc. of the Royal Soc.*, April 7th, abstracted briefly in the *London Elec.*, April 24th, KOHLRAUSCH offers a new and interesting hypothesis of the nature of ionic mobilities, based on the latest determinations. According to this the ion carries with it a mass of adhering solvent, which he calls its "atmosphere." The atmospheres of multivalent or compound ions differ from those of monatomic ions. He thus attempts to reduce the properties of ions in electrolytes to one fundamental element, i. e., their hydration or power of forming an atmosphere. The water atmosphere formed varies according to the nature of the ion, while the mobility of this complex and its temperature coefficient are functions of these atmos-

pheric formations. In general, the existing knowledge about the molecular forces is insufficient to describe this connection more exactly. "But for the case in which the water cell is so thick that the ion exerts no force beyond it, the resistance to motion becomes simply a matter of water friction, which explains the fact that the most sluggish ions have nearly the same temperature coefficients as the viscosity." If the electrolytic resistance is in reality a mechanical friction, it follows that the mobilities of all the ions converge toward zero at about the same temperature, namely 40° below zero.

Solutions in Amyl Amine.—An account of an experimental investigation of the electrical conductivity of solutions in amyl amine is given in the *Jour. Phys. Chem.*, April, by KAHLENBERG and RUHOFF. Silver nitrate, cadmium iodide and ferric chloride are soluble in amyl amine, and the resulting solutions are electrolytes, although rather poor ones, compared with aqueous solutions. Some of the interesting results obtained are as follows. The molecular conductivity dwindles to nearly nothing in a silver nitrate solution about $\frac{1}{82}$ normal, which is by no means a very high dilution. In the cadmium iodide solution the conductivity is equally low when the solution is as strong as one gram-molecule in 5.5 liters, and the ferric chloride solutions when still far from very dilute, also show a low molecular conductivity. This is interesting in studying the role of the solvent in causing electrolytic conduction. In these amyl amine solutions the ability of the solvent to produce with the solute a liquid having electrolytic conductivity is slight. The molecular conductivity of strong solutions of silver nitrate and cadmium iodide, increases as the solutions are diluted, but after passing a certain point, the maximum, the solute and solvent are no longer able to influence each other so as to give increased conductivity, and a further addition of the solvent therefore leads to a lower conductivity. From the point of view of the Nernst-Thomson theory, the conductivity of solutions in amyl amine is relatively high as compared with solutions in chloroform and ether. A comparison of existing data on the conductivities of solutions in solvents in the series in which liquid ammonia is the first member, methyl amine the second, and amyl amine a "higher homologue," would indicate that the conductivity of the solutions diminishes as the solvent occupies a higher position in the series. This behavior is similar to that found in other homologous series of solvents; the series of the primary alcohols, of which water may be considered as the first member, presents a typical example.

Action of Hydrochloric Acid Solutions in Various Solvents Upon Metals.—The opinion is often expressed that there cannot be any chemical action except between ions, and that the presence of water or moisture is an essential condition for enabling a chemical action to take place. Kahlenberg, however, has shown that the oleates of copper, nickel and cobalt dissolve in benzene to form non-conducting solutions, and that dry hydrochloric acid gas precipitates instantly the chlorides of these metals. He also found other similar and analogous reactions. In order to further study the action of chemicals upon each other in solutions in which the conduction of electricity is extremely slight, PATTEN has dissolved gaseous hydrochloric acid in various solvents, and brought the resulting solutions into contact with a number of metals and carbonates. In some cases hydrogen or other gas was evolved from the metal, and a chloride of the metal was formed; while in others one metal was attacked and this metal deposited from solution upon a second metal. In still others, no gas appeared and no deposition of metals upon each other was noted, but still some metals were corroded, and some solvents of themselves attack the metals. The arrangement of the apparatus and the results of his experiments are described in detail in the *Jour. Phys. Chem.*, March. It appears that the presence of water is not a necessity in order that chemicals may react upon each other. A chemical system need not conduct electrolytically in order that chemical action may take

place. Chemical individuality and chemical affinity are the main factors in chemical reactions, while temperature, pressure, surface conditions, and the masses of the acting substances, also exert great influence upon the nature, direction and extent of the reaction. In general, a chemical reaction goes on in such a way that the potential energy of the system is reduced to a minimum. The impulses which initiate chemical action require further study. The probability is that a vibration of a proper period must be set up in the system before chemical reaction will take place, and on this basis we can understand why certain reactions require a definite temperature; likewise why substances are stable between definite limits of temperature. While the mass of evidence disposes of the idea that chemical reactions go on, even in the most common cases, because of the previous splitting up of the substance into ions, yet it remains to explain the fact that a third substance facilitates chemical action. In many cases the union of reacting substances into a complex compound, and their subsequent splitting off in altered form, is a demonstrated fact. The union of solvent and solute in solution, and the many reactions which take place in solution, fall directly in line with the explanation of the function of a third substance. There is an interesting appendix to this paper, referring to a statement of Remsen that he had been unable to get hydrogen by acting upon dry zinc with hydrogen chloride dissolved in dry benzene. This is in contradiction with Kahlenberg's results. The present author shows that Remsen's failure was due to the fact that moisture was not excluded in his experiments. Kahlenberg's results are confirmed.

Electrolysis of Water.—Bigelow recently made a very extended series of experiments on the continual electrolysis of water at voltages below the decomposition value, a subject which has attracted the attention of many. WHITNEY, in a recent article in the *Jour. Phys. Chem.* for March, thinks that a strict application of the Nernst formula for e. m. f. of polarization would explain all the phenomena observed and described by Bigelow without the necessity of introducing any new corpuscular hypothesis. Whenever an electromotive force is applied to a pair of electrodes in an electrolyte, if its value is too small for visible electrolysis, there immediately occurs at least such an amount of real electrolysis as is capable of changing the poles into electrodes whose characteristic e. m. f. is equal and opposite to the impressed e. m. f. The earliest experiments on polarization point to this as a fact. In the case of an aqueous solution, the electrodes at 1 volt impressed e. m. f. are so charged with oxygen and hydrogen that they are to be considered as gas electrodes of low gas concentration or pressure. The gases can escape as bubbles only when the concentration has at least reached that value at which a gas pressure equal to that upon the liquid is reached, i. e., the atmospheric pressure. As the gases, when dissolved in the electrolyte, are capable of depolarizing the electrodes, especially the hydrogen and oxygen electrode, a current at very low voltages seems a necessary result. It should depend largely on diffusion and convection, as the actually studied current evidently does. In the decomposition of water by the current in general, electrical energy and heat are both absorbed, but the quantitative relation between the two varies with the conditions. Moreover, at a given temperature it varies with the pressure, so that at low pressures less electrical energy should be necessary than at high, although the total energy should be the same in all cases. The total energy difference between the water and its gases will be the same at a given temperature for all concentrations because of the constancy of the value of the product of pressure and volume for these gases, but the difference in free energy will depend upon the pressure and volume of the gases, for the greater the volume the less the free energy which they contain. The electrical energy obtainable from these gases under ideal conditions is a measure of the free energy they contain. At great attenuations this would become very small, though the heat of

reaction would be the same as before, conversely, the decomposition of water into these attenuated gases requires the application of but little work. The quantity factor of the electrical energy necessary to decompose the water is the constant of Faraday's law, but the intensity factor by which this must be multiplied to give the energy necessary is the e. m. f. of polarization. This, in accord with the Helmholtz-Nernst conceptions, is a function of the concentration at the active electrodes. Whitney claims that Bigelow's experiments support this view.

The Disintegration of the Anode.—In a very long discussion of this subject by WOHLWILL, he first treats of the formation of the anode slime in electrolytic refining. This, he says, is mainly due to the non-uniform composition of the anode. Particles of poor conductivity are embedded within those of good conductivity, and when the latter go into solution those of poorer conductivity drop into the slime. The author points out, however, that if an absolutely pure and uniform copper anode is used, in pure sulphuric acid, there is observed the formation of a fine red powder on the anode. He believes that this must be a precipitate from the electrolyte, but as it is formed from the beginning of the electrolysis of sulphuric acid free from copper, the only possible assumption is that this powder is formed by the discharge of freshly-formed copper ions. He assumes that cuprous ions go into solution, which as soon as formed are changed into cupric ions and uncharged metallic copper, the latter appearing in the form of powder on the anode. The author gives an account of a long series of experiments in which he endeavored to find quantitative relations for his theory and discusses the difficulties of these experiments. He gives a long list of facts which support his theory, both of which are given in the *Zeit. f. Elektrochemie*, April 23d.

Electrolytic Oxidation of Aromatic Compounds.—In the *Zeit. f. Elektrochemie*, April 30th, SENOR gives an account of some experiments in which he investigated the conditions under which aromatic compounds can be oxidized electrolytically. In the special case investigated by him platinum and lead anodes are used, and the latter were found greatly preferable. In order not to get too low a current efficiency, a high current density is to be used, but the current is nevertheless small.

Unipolar Induction in Electrolytes.—This improperly-named phenomenon is that which takes place when one tries to send an alternating current through a solution when one electrode is aluminium. The result is that the current can pass in only one direction, and hence, in a sense, will be rectified into a direct current, or more correctly, all that in one direction will be stopped by this so-called aluminium check valve. ISENBURG made some experiments recently with direct currents. He electrolysed a 1.5 per cent. solution of a mixture of NaNO_3 and Na_2CO_3 with lead electrodes and measured the e. m. f. of the cell as well as that of each electrode against an auxiliary cadmium electrode. The e. m. f. of the cathode against the cadmium plate remained constant, while that of the anode increased. The e. m. f. of the cell increased in six hours from 1.6 to 30 volts. On the other hand the e. m. f. of the polarization current, which was also determined, increases from 1 volt to only 4 volts. He concludes that the enormous rise of the e. m. f. of the cell is due to the foundation of a layer on the anode, which is a bad conductor. This is similar to the behavior of an aluminium anode when used as an electrolytic valve. Here there is also a formation of a layer of poor conductivity, and at the same time there is a condenser action. His experiments are described in the *Zeit. f. Elektrochemie*, April 9th.

The Dissociation Constant and Identity and Purity of Organic Compounds.—SCUNDER recently made a long investigation of the reliability of the dissociation constant as a means of determining the identity and purity of organic compounds,

from which he concludes that the dissociation constant is a moderately reliable aid to identification, but its use is limited. If, for any compound, the constants found by different observers agree within 10 per cent., the agreement is satisfactory, but the agreement between the values of the constants at different dilutions does not give a satisfactory guide to the purity of the compound that is being measured. This fact lessens the reliability of the constant as a means of identification. For further details see *Jour. Phys. Chem.*, April.

Chemical Affinity at Very Low Temperatures.—MOISSAN and DEWAR have made some experiments with the reactions of liquid fluorine at -187°C , which will be found in *Comptes Rendus*, March 30th, or *L'Electrochimie*, April.

PRIMARY AND SECONDARY BATTERIES.

Preparation of the Active Material for Lead Storage Batteries.—There is probably no one who has made more extended researches to try to find binding materials for the active matter in lead accumulators than LEIMER (whose name in German, by a curious coincidence, means one who glues or pastes). The first parts of his very long paper have already been noticed in the Synopsis for April. The conclusion is given in the *Centralblatt f. Accum.*, March 15th, where the results obtained with the various preparations of the active mass are given. He divides the various materials, used to make the mass more coherent and durable, into two classes: First, those which of themselves are of a pasting nature, like glue; second, those which produce greater adherence by chemical action. To the first group belong cobbler's wax, amber, collodium, gelatine, sugar, etc. These materials give to the lead oxide a strong mechanical firmness and a high electric resistance of greatly varying value. The principle of the second class is to mix the lead oxides with chemical substances which change a portion of the lead oxides during the pasting and drying process mostly into basic lead compounds, which grow out of the lead oxide particles and thus produce a very firm mechanical connection between the latter. On account of the high percentage of lead contained in them, the resistance of the active mass is relatively very low. The durability of such active masses is also great. To this class belong sulphuric acid, many organic substances, organic and inorganic salts and bases, if free from chlorine. The exceptions are carbon hydrates, oils, etc. There are systems in which the positive active mass is formed with 160 ampère hours per kg, while the change of minium into peroxide theoretically requires 147 ampère hours, and it is possible with a low watt load to get up to 105 ampère hours per kg of positive active mass, presumably referring to a subsequent discharge of the finished plates, but this was possible only when the best materials of the above second class were used. With materials of this class it is necessary to take care not to use anything which would have a destroying effect on the lead support. Moreover care should be taken in mixing two such materials together. He mentions instances in which two materials, each of which gave good results when used alone, gave bad results when mixed together. The author, in conclusion, mentions the following method of making an active mass: It consists in bringing the lead oxides mixed with pure water and after having been pasted into the frames of grids, into an air-tight closed drying oven, through which the materials which should give greater coherence and durability were passed in vaporized form. Since 1898 batteries made by this method have been in continuous operation for benzine automobiles, and have proved very successful. When he used pyridine for this purpose, which smells badly, then the vapor which left the drying oven had a pleasant odor like amyl acetate. It was surely no longer pyridine, hence had acted chemically on the plates. The same method may be successfully used for hardening old plates which have become soft.

Electric Lighting of Railway Cars.—GOETZE continues his illustrated article on the various systems used for the electric

lighting of railway cars with the aid of accumulators in the *Centralblatt f. Accum.*, April 1st and 15th, May 1st.

GENERAL AND MISCELLANEOUS.

Acetylene Central Stations.—The first two acetylene central stations in Germany were opened in 1897 and proved so successful that many more were erected in 1899 and 1900, so that at the beginning of 1900 there were 25 stations in operation, after which the progress was slower. The reason for the latter seems to have been mainly that the first installations erected were more or less experimental, and that their cost and the repairs or extensions which later become necessary required so much capital that no dividends were earned. VOGEL, in a recent lecture before the German Acetylene Society, believes that now, after experience has been gained, the commercial prospects are much more promising, and he recommends, the erection of an acetylene central station for any town having up to about 8,000 or 10,000 inhabitants. A condition which must be fulfilled for commercial success is that the houses must not be scattered too much. There should be at least about 150 lights for each kilometer of street pipe, if the gas is to be sold at 45 cents per cubic meter, the present price of calcium carbide in Germany being given as \$7 per 100 kg. He claims that the operation of an acetylene central station is much simpler than that of any other gas works and that no other gas is hygienically as safe. The fear of the danger of explosions has been greatly exaggerated. The main point is that the first cost of the plant is very low. For a town of 4,000 or 5,000 inhabitants with a pipe network of 8 km length, with 80 to 100 street lamps and a total of 1,500 connected lights, and a gas reservoir of 100 cubic meter capacity, an acetylene central station can be built for \$17,500, while another gas plant of the same size would cost at least \$40,000, and an electric plant \$50,000. In conclusion the author reproduces reports of physicians who state that for the eyes acetylene light is the best for reading. His lecture is published in the *Zeit. f. Calciumcarbid Fab.*, April 3d.

An illustrated description of the acetylene central station in Döse, Germany, is given in the same journal for May 8th.

An article by KEPPELER on impurities in commercial acetylene and on its purification is given in the same journal for April 9th and May 1st.

Decay of Metals.—MILTON and LARKE have made some experiments to determine the galvanic action between copper, iron, brass, Muntz metal, etc., when in contact with sea water. Other experiments showed that weak applied currents, when long continued, had a decided corrosive action upon copper and its alloys when immersed in sea water, the amount of corrosion with the same current being greatest in those alloys containing the highest proportion of copper. With a current of 0.001 ampères acting on an immersed area of 40 sq cm in the case of Muntz metal, the wasting produced was confined to the dezincification of the constituent poorest in copper, but the same current, acting upon 60 sq cm of ordinary brass condenser tubes, gave rise to a fairly uniform corrosion, both the copper and the zinc of the alloy being dissolved. It appears that decay was more frequent in metals which had a duplex or more complex structure than in those which were comparatively homogeneous, and was due to a slower or less energetic action than that causing corrosion. Moreover, it involved an action which removed only part of the constituents of the metal, whereas corrosion might result from chemical action alone, or from chemical and electrolytic action combined. Pitting, or intense local corrosion, was probably often due to local segregation of impurities of the metal, but it might also in some cases be due to local irregularities of surface or structure producing local irregularities in the distribution of the galvanic currents. In the case of brass exposed to sea water, tin was distinctly preservative, while lead and iron were both injurious, rendering the brass more readily corrodible. The percentage of the latter elements should, there-

fore, be kept as low as possible in all metal intended for purposes where contact with sea water was inevitable. The experiments with an applied current show that electrolytic action alone, even where exceedingly minute currents were in question, might result in very severe corrosion or decay. Every effort, therefore, should be made to prevent such action by careful insulation of all electric cables. Where galvanic action was inevitable through the proximity of different metals exposed to the same electrolyte, the resulting currents should be "neutralized" (sic) by the application of zinc plates in the circuit, so arranged that they would be negative to both of the other metals. Their experiments were described in a paper read before the (Brit.) Institution of Civil Engineers, an abstract of which is published in the *London Elec.*, April 24th.

Separation of Metals by Electrostatic Means.—The use of electrostatic forces to separate metals from their ores, or from each other, seems to be meeting with some favor. A method of this kind is in commercial use in Denver. NEGRESNO has made some experiments in this direction which he described before the French Academy, an account of which is published in *Comptes Rendus*, April 20th, an abstract of which appears in the *London Elec.*, May 8th. He cut a central disc out of a horizontal metallic plate and connected it to the positive pole of a Wimshurst machine, the remaining part of the plate, which is separated slightly from the disc, being connected to the negative pole. He then dusts a mixture of sand and finely-divided metal upon the plate and disc, and finds that the sand is deposited upon the disc and the inner rim of the plate, while the metal is deposited near the outer rim of the plate. In another form of the experiment the plate is left whole, and a separate disc is attached to the positive pole and brought near the plate from above. When a mixture as before is dusted upon the plate, the metal is driven to its outer edge, and many of its particles fly up and deposit themselves on the upper surface of the disc. The experiment succeeds very well with a mixture of sand, copper or bronze, almost the whole of the metal being transferred to the disc. The particles then transferred follow very closely the lines of force as traced out in a condenser. The method may be useful in the separation of metals from their ores, and also in the separation of two mixed metals; thus in a mixture of powdered brass and copper, the brass is repelled and deposited on the upper disc.

Electric Power in Mines.—The *Zeit. f. Elektrochemie*, April 16th, has an article by SCHNEIDER on electric installations of various mines in Germany. Some researches on the utilization of blast furnace gases in gas engines are referred to. The engines have recently been greatly improved, and the difficulties due to the lack of uniform composition of the gases, their impurities and their relatively small caloric value, have been partly overcome. He believes that there is no doubt a great future for the blast furnace gas engine. Many coal mines have a gas which is even more suitable for gas engines. The coke ovens give an average of about 25 per cent. greater gas volume than that required for heating the furnaces. The caloric value of the gases averages 4,000 calories. With these numbers as a basis, a battery of 50 furnaces would give a surplus of 520 cubic meters of gas per hour, which when burned under boilers gives about 300 h.p., but when used in gas engines about 655 h.p. In the coal mine region of Westphalia about 100,000 h.p. are thus available. Several such plants are now installed in Germany.

Measuring the Temperature of Furnace Gases.—The *Lond. Elec.*, March 27th, notices a paper by PRICE, read before the Manchester section of the (Brit.) Inst. Elec. Eng., on the use of the potentiometer in the measurement of temperatures of flue and furnace gases. With a reflecting galvanometer, used in conjunction with a potentiometer and a thermopile, the recalcitrant points of steel and copper were shown. The author's thermopile was composed of platinum and an alloy of platinum and iridium, and, with temperatures of about 2,000°

F., readings are said to be obtained with an accuracy of 10 degrees. The chief use to which the apparatus has been put was that of testing samples of magnet steel. Pooley remarked that he thought the method of taking furnace temperatures by means of the resistance of a platinum coil inserted in the furnace was the one most generally used, and was quite simple, as the resistance of platinum varies very regularly with different temperatures.

Russia.—*Cassier's Mag.* for April contains an illustrated article by HEENAN on electrical developments in Russia. The progress of the electrochemical and electrometallurgical industries is interwoven with the utilization of hydraulic power for current generation. There are several electrolytic copper refineries, a calcium carbide plant and a large caustic soda plant. Electric welding is in use in a number of works. Cables and storage batteries are made in some Russian factories.

Hydraulic Power-Station Statistics for France.—There is a long table, by COIGNET, in *L'Ind. Elec.*, April 10th, giving some statistical data on hydraulic stations in France. It states what they manufacture, where they are located, the height of the fall and the hydraulic power "en poncelets" (presumably in horse-power). There are three aluminium plants, power 16,802; five electrometallurgical plants, power 15,166; two potassium chlorate plants, power 6,750; fifteen calcium chloride plants, power 72,063; one sodium and chlorine plant, power 10,125; twenty-one stations for distributing electric power and light, power 28,067; twenty-two printing and paper mills, power 9,551; four textile mills, power 695; one saw mill, power 60; six cement factories, power 1,913; two potteries, power 151.

Electrochemistry in the United States.—Professor HABER was sent to this country last year by the German Bunsen Society to report on the development of the electrochemical industry in this country. This report has now appeared in the form of a long lecture, giving a summary of the methods of teaching electrochemistry in America universities, and of the industrial development of electrochemistry in the United States. It is published in the *Zeit. f. Elektrochemie*, April 16th and 30th, and will be found abstracted at considerable length in the present issue of ELECTROCHEMICAL INDUSTRY.

Book Reviews.

A TEXT-BOOK OF INORGANIC CHEMISTRY. By Dr. A. F. Holleman. Translated by H. C. Cooper, Ph.D. New York: John Wiley & Sons. Price, \$2.50.

We have here a text-book of inorganic chemistry, which has been written for a purpose. The author says in the preface that when the original Dutch edition appeared no text-book of inorganic chemistry existed in which the modern views introduced by van't Hoff, Ostwald, Arrhenius and others were sufficiently regarded, and that he therefore wrote it as a guide for his lectures.

His book is, however, not a text-book of physical chemistry (of which we have several of merit in the English language), but a text-book of inorganic chemistry, in which, with a moderate amount of descriptive matter on the elements and their compounds, we have a continuous effort to explain chemical phenomena as observed in the lecture room, the laboratory and in manufacturing practice by the newer physical theories and laws. Many of these explanations are extensively ingenious, and at the same time satisfying; others are at least plausible. Let us take, for example, the discussion as to the character of hydrochloride acid, on page 39. The author shows that hydrogen chloride does not follow the law of Henry in its behavior towards water; that its solubility is not at all proportional to its pressure, and that the chemical properties are found to be quite different when it is in a perfectly dry condition, as gas or condensed to a liquid, and when it is dissolved in water. This difference he shows to be clearly due to dissociation of the hydrogen chloride in solution. The whole theory of dis-

sociation is clearly stated on pages 76 to 81, and shown to be a sequence of the law of mass action, and electrolytic decomposition is simply shown to be a grouping together at the electrodes of the ions already separated by the process of solution. This leads the author, on page 100, to give a new definition of acids and bases more in accord with these views than the familiar one of most text-books. Acids he defines as "those substances which give H ions in aqueous solution; bases, under the same conditions, give OH ions."

The theory of osmotic pressure and its analogy to the laws of Boyle and Gay Lussac for gases is also very clearly explained on pages 56 and 57, and the application of this theory in measuring the depression of the freezing point and the elevation of the boiling point of liquids and the value of this in determining molecular weights is then shown, and the methods explained and apparatus described on pages 64 to 67.

Most interesting is the application of the ionic theory and the deductions therefrom to explain the phenomena of precipitation under varying circumstances, as, for instance, why some elements are precipitated from acid solution by hydrogen sulphide and others not, as given on pages 115 to 118; and, again, the effects of hydrolytic dissociation on precipitation phenomena in general, as stated on pages 328 and 329.

The theory of ammonium salts and the readiness with which some of them yield ammonia is also well stated and explanations given on page 315. The theory of electrolytic dissociation is very ingenuously brought in to explain the basic or acid reaction in the case of some salts called neutral from the point of view of their chemical constitution, and illustrative cases given on page 328.

Among the practical applications of some of these physico-chemical theories we have, on page 391, the account of the different behavior of tinned sheet iron and galvanized iron. Tinned iron, if scratched at any point, rusts faster than iron alone, while galvanized or zinc-plated iron does not rust even where the plating is worn off. This, the author explains, is due to the fact that in the presence of moisture, as an electrolyte, the metal with the greatest solution tension goes into solution and the steel remains intact.

Of course, the periodic system of the elements is given a very full and thorough presentation, and the arrangement of the book is that indicated by this method of grouping. The value of the periodic system in indicating the relative position and relationship of newly-discovered elements is very well explained. Lothar Meyer's well-known curve, in which the elements are plotted, follows in the rear of the book on a plate.

The book is, throughout, very suggestive to a thinking student of chemistry, and will undoubtedly point out the explanation of many apparently little-understood phenomena, and perhaps contradictory phenomena. It is, in general, free from errors. One may be pointed out, however—at the top of page 56, where the formula of white lead is given as $PbSO_4$, instead of the basic carbonate.

We feel that the American translator has performed a useful service in bringing out this American edition, and making the book more widely known.

THE MINERAL INDUSTRY. Founded by the late Richard P. Rothwell, edited by Joseph Struthers, Ph. D. Vol. X for the year 1901. New York: *Engineering and Mining Journal*. Price, \$5.

JAHRBUCH DER ELEKTROCHEMIE. Founded by Prof. W. Nernst and Prof. W. Borchers. Vol. VIII: progress in 1901. Edited by Dr. H. Danneel. Halle: Wilhelm Knapp. Price, \$8.

KALENDER FÜR ELEKTROCHEMIKER for the year 1903. Edited by Dr. A. Neuburger. Berlin: M. Krayn. Price, \$1.35.

As these are three annual publications of interest and importance to electrochemists, they may be reviewed together.

Mineral Industry, of which we have the tenth volume, referring to the progress made during the year 1901, is so well

known and the completeness and reliability of its statistical data are so fully recognized by everybody interested in the mineral and metallurgical industries that it would be superfluous to dwell on this at length. We may simply say that under its new editor, Dr. J. Struthers, the high standard set by the late R. P. Rothwell has been fully maintained. Articles of an electrochemical nature have been contributed to this volume by J. B. C. Kershaw, Titus Ulke and R. L. Whitehead. As with the former volumes, part of this volume was published before in articles appearing in the *Engineering and Mining Journal*. When a new volume of *Mineral Industry* appears most of the information contained in it is somewhat old, but this is an inherent and unavoidable disadvantage of every annual publication. The ten volumes of *Mineral Industry* form the most complete review of the mineral industries in the last ten years.

A relation similar to that between *Mineral Industry* and the *Engineering and Mining Journal* exists between the *Jahrbuch der Elektrochemie* and the *Zeitschrift für Elektrochemie*. The German year book was founded in 1895 by Dr. W. Nernst and Dr. W. Borchers, who at that time were the editors of the *Zeitschrift*. The greatest part of the first volume was written by Nernst and Borchers, but in the following years a greater staff of contributors was won, and Nernst and Borchers acted more and more as editors only. This they continued to do up to the seventh volume. The eighth volume, referring to the progress in electrochemistry during 1901, has been edited by Dr. H. Danneel and the following gentlemen acted as reviewers: Dr. H. Danneel for general scientific electrochemistry, conductivity of solutions, theory of galvanic cells, polarization and electrolysis, radiant and chemical energy; Dr. M. Muggan, for storage batteries; Dr. P. Askenasy, for industrial progress in inorganic electrochemistry (except metals); F. von Kuegelgen, for industrial electrometallurgy; Dr. K. Elbs, for industrial progress in organic electrochemistry; Dr. W. Borchers, for apparatus for electrochemical practice. There is also a chapter on Becquerel rays by Dr. F. Harms.

The general policy of the *Jahrbuch* has remained the same under the new editor who has fulfilled his duty with remarkable skill. The size of the book has increased again. It has now 725 pages, of which 373 refer to theoretical electrochemistry, and the balance to industrial electrochemistry. The eight volumes of the *Jahrbuch* are certainly the most complete, although somewhat unwieldy, record of the progress in theoretical and industrial electrochemistry since 1894. The reviewers have endeavored not to give simply a record of what has been done or what is claimed to have been done, but they have added critical notes. This is to be recommended as far as it goes, although in industrial electrochemistry practice alone has the last word, and in theory it is not sufficient to make an ironical remark in order to kill an opponent.

Neuburger's Kalender für Elektrochemiker was first published in 1896, and was evidently written to give to electrochemists a pocket-book of the same nature as the German electrical engineers have in Uppenborn's well-known *Kalender*. To keep such a calendar up to date it must be carefully reviewed and overhauled every year. In this respect the last edition of *Neuburger's Kalender* shows a marked improvement over the former editions in which the information given had become quite stale. We hope the editor will continue to work in the same direction in future issues. To make the information given in such a small pocket-book complete, concise and up to date the continual work of years is required. The *Kalender* contains many very useful tables on subjects of electrical and mechanical engineering, chemistry, physics and electrochemistry. The part dealing with electrochemistry proper comprises 300 pages, the contents of which are as follows: Fundamental laws, table of electrochemical equivalents, tables of transport numbers and ionic mobilities, tables of conductivity of dissolved and fused electrolytes, polarization, single potentials of electrodes, tables of decomposition voltages,

description of galvanic cells and batteries with rules for manufacturing, installing and maintaining them, electrolytic analysis, tables of formation heats, some notes on industrial electrochemical processes, and prescriptions for electroplating.

Correspondence.

COST OF ELECTRICAL STEEL PROCESS.

To the Editor of ELECTROCHEMICAL INDUSTRY.

SIR:—I had hoped that some one of your readers would have criticised the figures given in your issue of March, purporting to be the cost of producing steel ingots at the Canonica Works, in Italy, using the Stassano process.

Not that I would for the moment doubt the accuracy of Dr. Goldschmidt's statement; he like "Caesar's wife" is above suspicion. The figures given, therefore, exactly represent the conditions, as found by him, existing at the time of his visit.

I had hoped, however, that some one of your readers would have pointed out that while the figures represent the working of the process, under the handicapping conditions existing at Canonica, which conditions were no doubt responsible for the stoppage of the works, yet they would not fairly represent the cost of the process under such conditions as are known to exist on this continent.

I am not conversant with kilograms and liras. In my translation, therefore, I may have made some mistakes, but it may be of interest to some to know in dollars and cents the costs found existing by Dr. Goldschmidt at Canonica, and to have these costs compared with the costs which might be expected to obtain at certain locations on this continent.

	At Cannonica	In America
3,540 pounds, or say 1½ tons of iron ore costing ..	\$1.80	\$1.75
Pulverization of same96	*
480 pounds, or say 1-5 ton of flux20	.12
550 pounds, or say ¼ ton of coke	2.25	1.50
Pulverization of same10	*
418 pounds, or a little over 1-6 ton addition	2.66	2.66
For making the mixtures	1.35	*
Wear of electrodes72	.72
Maintenance of furnaces	2.40	*
Wages	1.20	*
Utensils60	*
Electric power	4.56	2.23
Incidental costs60	*
Labor		2.50
Repairs, renewals, utensils and sundries		2.00
Totals	\$22.40	\$13.48
**Less volatile and combustible gases obtained. 3.60 3.60		
	\$18.80	\$9.88

It will be noted that at Canonica none of the raw materials are cheap, nor is the power, while the wages and repairs, etc., are extravagantly high—caused doubtless by local conditions—such as distance of works from the railroads, size of the plant and variable water supply; the consuming market was also very far away, labor costing \$3.61; power, \$4.56; repairs, etc., \$3.60, against \$2.50, \$2.23 and \$2.

LOUIS SIMPSON.

OTTAWA, CANADA.

ELECTRIC AUTOMOBILE CHARGING OUTFITS.

While the problem of devising a light storage battery is the most important one for electric automobile people, the question of an inexpensive and thoroughly reliable charging outfit is also a vital one. The efficiency of the electric automobile mainly depends upon the performance and maintenance of its

*This item could probably be largely reduced.

**These gases could be used for the conversion of the iron into steel—so far as they would go.

battery, and for its proper care it is necessary that the charging station shall, in its turn, satisfactorily meet all the practical requirements of every-day service, including use by those unfamiliar with storage-battery charging and limited opportunities for attention thereto. In the following we give a description of a charging outfit of the Westinghouse Electric and Mfg. Co.:

Charging may be derived from any one of three sources—direct current, alternating current or independent power. Combinations and variations admit of 168 different styles of charging outfits, a sufficient variety to meet any and all of the peculiar conditions or demands of either the private or public charging stations. With these combinations one, two, four, twelve or more automobiles can be charged at once. The outfits for charging one or two machines are intended for private use; that with a capacity of four is suitable for clubs, country houses or small stables, while the standard twelve service is applicable for use by public garages, express and cab companies, or other establishments having a number of vehicles.

One of the chief advantages of the garage installation shown in Fig. 1, the only one having this valuable feature, is that all controls are at one point, with minimum apparatus, instead of, as in the former practice, having them individualized and spread over considerable space, involving double the trouble and expense. There is also a saving in that, instead of being compelled to use 12 voltmeters and 12 ammeters, one of each is sufficient.

Another important item is that the charging may be in serial or simultaneous. The cut shows one of these garage switchboards with the series rheostats installed below it for controlling the charging rates of the various batteries. In this particular case rheostats are provided for eight vehicles, the

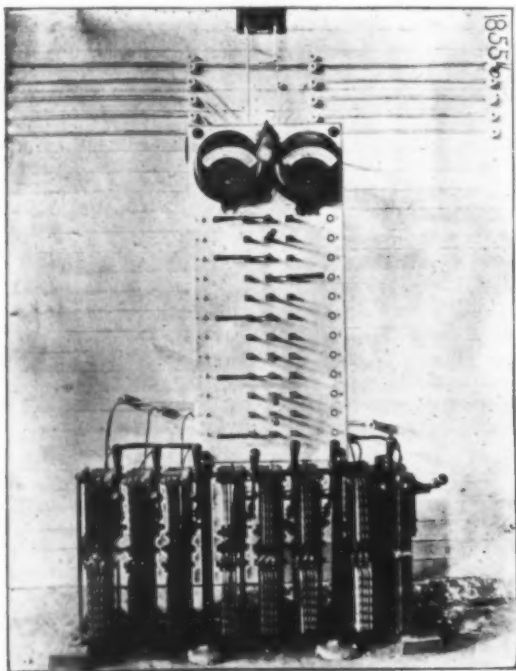


FIG. 1.—CHARGING OUTFIT FOR AUTOMOBILES.

greater capacity being obtained at any time by adding the requisite number of rheostats.

Each switch on the board is numbered to correspond with the number of its rheostat and charging stand. The throwing of a switch to the left places a battery in "charge;" reversing to the right connects the ammeter so that the current may be read. The voltmeter will indicate for the whole main line, or by pressing the push button corresponding to any switch the

voltage reading of its stand can be taken. A separate push button gives the voltage reading on the line beyond the rheostats. Opposite each switch is a numbered hook, upon which the charging record of the battery may be kept.

In connection with this central switchboard automatic circuit breakers and fuse blocks are to be used at each charging stand. These switchboards may be connected with any 125-volt, direct-current line, whether from central stations, motor-generator set or independent circuit.

For the one or two vehicles of the private owner, or the small garage designed for four machines, the panels are as shown in Fig. 2, with the necessary modifications in each case, and are adapted for direct-current voltage of 110 to 125. For single charging, the automatic circuit breaker is mounted directly upon the panel, with the meters and fused switch. Where two or more automobiles are to be charged, the circuit breakers are displaced by switches, and the overvoltage circuit

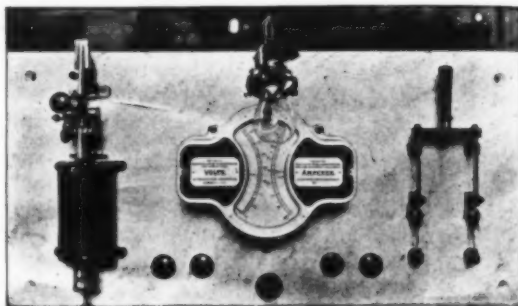


FIG. 2.—CHARGING OUTFIT FOR AUTOMOBILES.

breaker and fuse blocks are located at the carriage-charging stands.

The details of the outfits are of standard Westinghouse make, and are as follows: The panels are of white Italian marble or marbelized slate. The meters, which, for private use, may be a combined voltmeter and ammeter, are provided with sub-scales and convenient terminals for reading voltages of individual cells, with volt scale from 0 to 150, sub-scales 0 to 3 and ampère scales 0 to 100. The switches are of standard Westinghouse type D, of the normal capacity of 50 ampères for each charging circuit, the line switches being fused. The circuit breakers, under normal circumstances, automatically cut out the battery when the charge is completed, and in all cases protect the battery from any overcharge danger or damage, enabling the owner or attendant to set the charge and pay no more attention to it until the machine is again wanted for use without loss or damage of any kind. The motor-starter rheostats, employed in starting the direct-current motors, are mounted on the back of the panels, with handle projecting through, the same as with the generator field rheostats. Where a generator is employed, the latter are used for the regulation of the battery charging of one carriage, without requiring the additional series rheostats of the grid or imbedded type. Where the series rheostats are needed, they are made in one of three types—grid, embedded or combined. In the first form they are mounted on the floor, directly below the switchboard, the grids being of cast iron, set in the open air, thoroughly ventilated, and, while they are normally made to carry 60 ampères each, they can be immensely overloaded without injury, surviving unhurt where other types burn out. This is an important point, since it obviates all danger of battery injury by the burning out of the rheostats, a danger that has been, and in some types still is, found only too frequently. The embedded type of rheostat is in two styles, designed for use with either 10 to 14 or 20 to 24 cells. When charged from a 125-volt line, each will carry continuously 30 ampères, and may be mounted with several of the same type or with the grid type.

One of the greatest advantages of the Westinghouse outfits is that they have no loose wires, thus doing away with all danger from fire. If, from ignorance or carelessness, a mistake is made by the operator, the fuses supply the deficiency by cutting off the current, obviating any injury to the batteries or switchboard. There is nothing complicated about them; nothing requiring technical training or skill; nothing that any man of ordinary mental capabilities cannot master in five minutes. They occupy but little space, the panels for private use being only 14 x 28 x 1 1/4 inches thick, and those for public garages 22 x 48 x 1 1/4 inches.

The direct or alternating-current motor generators furnished by the Westinghouse Electric and Mfg. Co. are of standard type, and adapted to the panel used, transforming high-voltage direct current to the proper voltage, or changing alternating current to the desired voltage direct current for charging. These present an advantage in that, being standard, they are always a marketable commodity.

In cases where the owner prefers his own isolated plant of gas or other power for driving a generator, accessory apparatus to meet the requirements has been added to the outfits.

THE ELECTROLYTE FOR STORAGE BATTERIES.

We have received from the Franklin H. Kalbfleisch Co., of New York City, a pamphlet, containing an article by Thos. J. Fay, on "Electric Storage Batteries and Electrolyte." It gives valuable information for practical men who have to do with storage batteries, especially for automobile purposes.

The theoretical remarks on page 10 are not up to date and, in view of the extended investigations of Dolezalek, it is not correct to say that the chemistry of the storage battery is by no means understood. But the author evidently does not want to write a theoretical paper, but wants to give practical rules for practical men, and in this purpose he is very successful. In the following we give some abstracts from the pamphlet:

For automobile practice the author gives the following directions for charging a battery: to charge a battery in three hours: first hour, 50 per cent.; second hour, 30 per cent.; third hour, 20 per cent.; to charge a battery in four hours: first hour, 40 per cent.; second hour, 30 per cent.; third hour, 20 per cent.; fourth hour, 10 per cent.; to charge batteries in five hours: first hour, 30 per cent.; second hour, 25 per cent.; third hour, 20 per cent.; fourth hour, 15 per cent.; fifth hour, 10 per cent. In cold weather, the three-hour charge is best, in hot weather the five-hour charge is necessary, but, under normal conditions of temperature, the four-hour charge produces the most satisfactory results.

It is undoubtedly a fact that charging at constant wattage is superior to all other means, but to do so requires that an automatic rheostat be devised; the resistance in circuit to be controlled by two magnets or solenoids in opposition, one of which energized by the charging current and the other by the battery e. m. f. Such a charging equipment is as yet not to be had, but the time is not far distant when manufacturers will see their way clear to devise the constant wattage automatic charging set, for vehicle work, at any rate.

When the batteries are fully charged, the operation of charging should be immediately stopped. The features which indicate that the charge is complete, are enumerated. For battery tests it is recommended to take readings of the single potentials of the two plates by means of an auxiliary cadmium electrode.

The author then deals at length with the problem of the electrolyte. Its strength or density is of great importance, and as it is measured by means of hydrometers, formulas are given which represent the relation between the specific gravity and the various hydrometer scales in use. He points out that the specific gravity of the acid in a storage battery should be between 1.200 and 1.300; to go above 1.300 specific gravity is

to risk destroying the plates. The electrolyte should be purchased ready for use, but if it must be mixed on the premises, proceed as follows:

To dilute sulphuric acid—

- (a) Provide a lead-lined tank of suitable size.
- (b) Wash the tank before use with distilled water.
- (c) Fill the tank three-quarters full with distilled water.
- (d) Stir in slowly, pure, concentrated sulphuric acid.
- (e) When the hydrometer shows that the specific gravity of the mixture is 1.175, discontinue the operation until the electrolyte cools off (it heats in mixing). Then take the specific gravity again. It will then be about 1.200. If, however, a 1.250 specific gravity electrolyte is wanted, raise the gravity of the hot mixture to 1.225, instead of 1.175. If the gravity is not exactly right, adjust it to a nicety when cold, by adding concentrated sulphuric acid to strengthen, and distilled water to weaken.
- (f) Do not use earthenware, iron or any other ware for mixing the electrolyte, excepting lead-lined tanks, glass or glazed porcelain, but porcelain-lined iron pots will not be a good substitute.

(g) When the electrolyte is mixed, put it into carboys, with stopper to keep it pure, until the time comes to use it.

The author emphasizes the enormous importance of absolute purity. He urges that tests for impurities should regularly be made, and gives clear directions how to make simple tests for undesirable ingredients, such as chlorine, iron, copper, mercury and nitrates. Distilled water should always be used, not water from the city mains. He sums up his recommendations as follows:

- (a) Test the battery when first received for impurities. If the battery comes "knocked down" or "dry," test the plates.
- (b) Test every carboy of electrolyte received before any of it is used, and, above all, do not purchase electrolyte made from iron pyrites. The only suitable electrolyte is made from sulphur for the acid, and distilled water for diluting.
- (c) Do not have concentrated sulphuric acid around, as some careless person may put it into the battery, either to bring up the strength of the electrolyte or by mistake.
- (d) Use only distilled water from carboys, not from barrels, and test every carboy of water received before using.
- (e) Keep the electrolyte up to strength in the batteries by the following process:
 1. Add distilled water to reduce the strength.
 2. Add 1.400 specific gravity electrolyte to increase the strength.
 3. Test for acid strength always with a fully-charged battery.

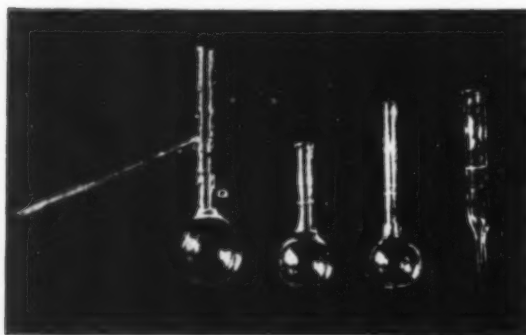
(f) Temperature has a marked effect on battery output and acid strength, hence observe the temperature at which all equalizing of electrolyte is done, and either compensate for temperature or wait until the temperature is at some predetermined point, say 60° F.

The pamphlet is concluded by brief, illustrated descriptions of the Gould, Manchester-Chloride, Willard, Porter and Sperry batteries.

The Franklin H. Kalbfleisch Co., who have published this, and other pamphlets on storage batteries, realized the necessity of having electrolyte free from impurities, and were the original manufacturers of pure electrolyte. Their electrolyte is guaranteed to be made from Sicily brimstone, sulphuric acid only, and to conform in all respects with the requirements for storage batteries, of all makes, either for central station work, electric vehicles, or any other uses to which storage batteries are put. They are also large manufacturers of distilled water, to be used in diluting, and make a specialty of these articles, as well as standard battery solutions and chromate salts. They will be glad to send a copy of the Fay pamphlet on request, and also send in addition, any future works which they may issue on the subject.

CHEMICAL APPARATUS MADE FROM QUARTZ.

Among the chemical apparatus exhibited by Messrs. Eimer & Amend, of New York City, during the recent convention of the American Electrochemical Society, there were crucibles, tubes and flasks blown and drawn of fused quartz. The adjoining illustration represents them in about one-fifth natural size. The credit for this latest achievement in labora-



APPARATUS MADE OF QUARTZ.

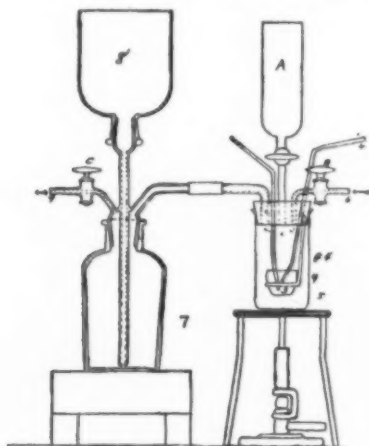
tory utensils is due to the firm of Heraeus, in Hanau, Germany. The quartz is not fused by means of the electric arc, but by the oxy-hydrogen flame.

Sudden, very large temperature variations have no effect whatever on the quartz apparatus. While it is still pretty expensive, it is cheaper than platinum for which it is intended as a substitution in various cases.

CARBON DETERMINATION APPARATUS.

Among the new apparatus exhibited by Messrs. Eimer & Amend, of New York City, during the recent convention of the American Electrochemical Society, there was a very interesting apparatus, designed by George O. Seward, the managing chemist of the Wilson Aluminium Co., for determining carbon, especially of the electric furnace products, like in ferro-chrome, etc.

The previous best method of determining the carbon in ferro-chrome and like materials which cannot be decomposed



SEWARD CARBON DETERMINATION APPARATUS.

and a platinum tube and boat, none of which are necessary in Mr. Seward's apparatus in which no platinum at all is employed. Perfect combustion is obtained by igniting the substance to be analyzed in a sodium peroxide mixture by means of an electric spark. The analysis is made in much shorter time than in any other method and is quite correct. The apparatus is very easily manipulated. The fusion and

by any solution, necessitated the use of a combustion furnace consequent oxidation of the metal and the carbon in the metal is complete in less than sixty seconds.

The adjoining diagram shows the construction of the apparatus which is operated as follows: A is filled with cold, distilled water, and the lower bottle at the left hand with concentrated sulphuric acid to the level indicated (it acts as a safety device to take care of the difference of pressure in the beaker at the right hand).

A 20 cc nickel crucible is then filled with 1 gram of the metal to be analyzed, intimately mixed with about 10 grams of sodium peroxide. The apparatus is then set up as shown in the figure, and purified air is passed through the train for fifteen minutes to expel any CO₂ which might be in the train. Two wires, the ends of which reach into the crucible, as shown in the figure, are now connected with a source of electric current, not more than 3 amperes being necessary or desirable at 110 volts.

The two stop cocks, B and C, shown in the figure are closed and the mixture in the crucible is fused by means of the small arc formed between the ends of the two wires in the crucible. The arc is started by touching the two ends and then separating them; after the fusion is started by this means, it will continue through the mass, if the proportions of the metal and peroxide were correct.

The pressure caused by the oxidation of the metal in the crucible will force the acid in the lower bottle at the left side up into chamber 8. A weighed KOH bulb is now connected in the train by means of the stock cock C and by opening the latter carefully the passing of the gases through the KOH bulb is commenced, to be continued until the end of the analysis.

When the fused mass in the crucible has cooled sufficiently, water is let into the fused mass and the beaker is filled nearly to the top of the crucible. The remainder of the water in A is then siphoned off and A is filled with a cold mixture of one part of water to one part of sulphuric acid. This is let into the beaker until the solution is strongly acid. The solution is then boiled for ten minutes to expel the CO₂, which may be left in the acid solution.

The stop cock at the right hand is then opened and air is passed through the train for fifteen minutes, when the KOH bulb is detached and weighed, the gain in weight being the CO₂. As the sodium peroxide on the market at present is not entirely free from carbonates, it is necessary to make a blank determination on each lot of peroxide to determine the amount of carbonates in the same.

The principal claims made for the apparatus are that the apparatus contains no platinum and is therefore very cheap; the operation of analysis is much shorter than by any other method and quite as exact; no hydrocarbons are formed in the combination, which is a decided advantage; the apparatus is very easy to manipulate and duplicate determinations can be carried on at the same time readily; no oxygen gas is used; the fusion and consequent oxidation of the metal and the carbon in the metal is complete in less than sixty seconds.

ALTERNATING CURRENT LONG SCALE VOLT-METER AND AMMETER.

The accompanying cut is an illustration of an improved form of voltmeter and ammeter. These are induction instruments, and in principle of operation are closely allied to the integrating wattmeter made by the same company, the Westinghouse Electric and Mfg. Co.

The scales begin at zero, and the divisions are absolutely proportioned and uniform above 20 per cent. of the full capacity, with a length and openness obtained in no other type, allowing the readings to be made with perfect accuracy. As an additional aid to easy and correct reading from a distance the dial is made of translucent material, illuminated from the rear, while the marking are distinct and the figures large

and prominent. The lamps for illuminating this scale are inclosed in a compartment separate from the rest of the mechanism, giving perfect ventilation and not heating the working parts.

In this type an electro-magnet produces a shifting magnetic field, in the air gap of which is an aluminium disc in which currents are induced by the field, resulting in the disc's movement. This motion being opposed by a spring, the amount of deflection is shown by a pointer mounted on the shaft of the disc. When the pointer is at the zero position, the outline of the disc being spiral, the air gap closes that portion of the disc having the longest radius. As the deflections increase the inclosed radii decrease, diminishing the pull on the disc until it becomes proportional directly to the current, resulting in a uniform scale of a length obtained in no other type.



These instruments are absolutely unaffected by external fields, are totally dead-beat, and are compensated for changes in temperature and frequency. The moving elements being very light in weight, the bearings perfect, finely-ground jewels and the shaft carefully hardened and polished, renders friction a negligible quantity. Made to certified and legal standards, they are calibrated with extreme care. The parts are interchangeable, and the cases dust-proof and of neat appearance.

Instead of requiring the main current to be brought to the instrument, necessitating in some cases expensive bus-bar connections, this make of ammeter is arranged to operate from 5 ampere secondaries of series transformers, thus enabling the instrument to be mounted at any convenient point.

INDUSTRIAL NOTES.

THE EMPIRE STATE-IDAHO MINING AND DEVELOPING CO., of Spokane, Wash., have purchased of the Westinghouse Electric and Mfg. Co. three motors for driving concentrating mill machinery and a large air compressor in the Cœur d'Alenes. These motors will be supplied with power from the 2,300-volt secondary circuits of the Washington Water Power Co., of Spokane, whose 50,000-volt transmission line is now extending into the Cœur d'Alenes in Northern Idaho, a distance of approximately 90 miles. There are two 150 horse-power, three-phase, 2,300 volts, 589 R.P.M., type "C" induction motors to be supplied; one for driving the air compressor of the Empire State mine at Wardner, Idaho; the other to operate the Sweeney concentrating mill, a short distance from Wardner. The third motor will be of the Synchronous type, 240 horse-power, 2,300 volts, three-phase, 514 R.P.M., and will drive the concentrating mill of the Tiger-Poorman mines at Burke, Idaho. These motors will be placed in operation about June 1, 1903.

We have received from Mr. F. BEHREND, New York, a pamphlet on stoneware apparatus for chemical and electrochemical purposes. Mr. Behrend is the sole importer of the

high-grade, acid-proof stoneware apparatus of the United Stoneware Works, Ltd., of Berlin-Charlottenburg, which is the consolidation of L. Rohrmann, E. March Soehne, Thonwarenerwerk Bettenhausen, and A. Kypke. The pamphlet contains brief, illustrated descriptions of various apparatus.

THE UNION IRON WORKS, of San Francisco, is installing a power transmission plant near Reward in Inyo County, California, from which it will transmit power electrically over a distance of about 2 miles to the mill of the Reward Gold Mining Co., where induction motors will be used to drive a 20-stamp mill, an air compressor and a rock breaker. The apparatus, which has been purchased from the Westinghouse Electric and Mfg. Co., includes a 120-kilowatt, three-phase alternator; a 2 horse-power exciter; a type "6" switchboard panel, including voltmeters, ammeters, rheostats, etc.; two 50 horse-power, type "C" induction motors, complete with auto-starters, slide rails, etc.; a 15 horse-power induction motor; three 7½-kilowatt O.D. transformers; two 1-kilowatt O.D. transformers, and 8 lightning arrester units. The transmission will be at 2,200 volts.

THE steam turbine plant of the Hartford Electric Light Co., Connecticut, which at present consists of a 2,000 horse-power set, is soon to be duplicated by machines built by the contractors for the original installation, the Westinghouse Machine Co. This was the first American plant where steam turbine units of large size were installed, and their complete success must be highly gratifying to the makers. In its application to the generation of electrical power the Westinghouse steam turbine is undoubtedly making marked progress, and in many instances is displacing the reciprocating steam engine for this class of work. As an evidence of this and the energy with which the manufacture of these machines is being taken up, it is stated that the aggregate power of steam turbine sets completed, in hand and in order to the Westinghouse Machine Co. does not fall far short of 200,000 kilowatts.

TRADE CATALOGUES.—We have received the following trade catalogues and pamphlets: From Eimer & Amend, New York, an illustrated pamphlet on their goods exhibited during the recent convention of the American Electrochemical Society, also their price list of minerals; from the Yagni Copper Co., New York, a very neatly printed and illustrated book, containing their initial report to the stockholders, with the report of H. I. Willey, engineer of mines; from the Boston Pottery Co., their catalogue No. 2 on their standard Akron stoneware; from the C. W. Hunt Co., West New Brighton, N. Y., catalogue 032 on foundry ladle cores and pamphlet 033 on coal handling machinery; from the Fort Wayne Electric Works, bulletin 1039 on small direct-current generators, 1040 on motor starting rheostats, and 1041 on direct-current belted motors; and from the Electrical Appliance Co., of Chicago, a well-illustrated catalogue on conduits and conduit fittings.

Personal.

MR. THOMAS A. EDISON has accepted the position of honorary chief consulting electrician to the St. Louis Exposition.

MR. JOSEPH B. HALL is now chief engineer of the McGuire Mfg. Co., of Chicago, having severed his connection with the General Electric Co.

AMONG the active members of the Bach choir at the recent Bach festival, held at Bethlehem, Pa., from May 11th to 16th, we noticed Prof. J. W. Richards and Prof. W. S. Franklin, of Lehigh University, and various engineers of the Bethlehem Steel Works.

PROF. R. LUEPKE, best known as the author of an elementary German treatise on electrochemistry, which has also been translated into English, died recently in Berlin.

PROF. J. J. THOMSON, of Cambridge, has arrived in this country for the purpose of delivering a course of lectures on the electronic theory before several universities.

MESSRS. E. P. ROBERTS & Co., consulting engineers, of Cleveland, Ohio, have opened a branch office at 25 Broad street, New York City. Mr. William C. Andrews will be the manager of the New York office.

Mr. F. O. Edson has been elected secretary and treasurer of the Bendit Mercantile Engineering Co., successors to Lanfetter-Bendit Mercantile Engineering Co., of St. Louis, Mo. Mr. F. C. Lanfetter retires to become president of the Victor Mfg. Co., of the same city.

DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

This digest of electrochemical United States patents prior to July, 1902, will be one by classes, setting out for comparison in each class those devices which have the same object, or those methods which seek the same results. In each class the patents will be arranged chronologically. The digest will be complete in the sense of covering every point which is touched upon in the original specification.

*Compiled by Byrnes & Townsend, Patent Lawyers,
National Union Building, Washington, D. C.*

BLEACHING AND DISINFECTING LIQUIDS.

294,619. March 4, 1884; E. Hermite, Paris France.

Electrolyzes an alkali chloride, especially sea salt, in a diaphragm cell, with electrodes of lead, obtaining caustic and lead chloride. The lead chloride "is mixed with water and a small quantity of hydrochloric acid, and subjected to electrolysis in the presence of textile fabrics," etc., preferably in a rag engine. A lead plate on the bottom of the engine serves as cathode, receiving the deposited lead. Over this is an insulated sheet of wire gauze. Above the gauze is the insoluble anode. Bleaching effected by the chlorine water produced. May substitute zinc, iron or tin for the lead anode, to electrolyze the alkali chloride, and then electrolyze the resulting zinc, iron or tin chloride to produce the chlorine solution.

378,681. February 28, 1888; E. Hermite and C. F. Cooper, Pownall road, Dalston, Middlesex, England.

Produces hypochlorites by electrolyzing chlorides. Anodes, horizontal tubes of platinum, metal-lined with platinum, plumbago purified by boiling in a mixture of hydrochloric acid and potassium chlorate, or glass, porcelain or hard rubber faced with plumbago. Cathodes, cylindrical rods of zinc which reciprocate through the tubes, leaving an intermediate space for the electrolyte. Scrapers bear on the zinc cathodes, to remove any deposit (magnesia). Bleaching solution continuously circulated between cell and bleaching vessel.

379,465. March 13, 1888; E. Hermite and C. F. Cooper, Dalston, Middlesex, England.

Produces magnesium hypochlorite by electrolyzing its chloride. Bleaching solution continuously circulated between cell and bleaching vessel. Anodes, a series of vertical platinum sheets, stiffened by a non-conducting frame, or plates coated with platinum. Cathodes, disks of zinc fixed on a horizontal shaft and revolving between the anodes. Scrapers remove the deposited magnesia.

381,372. April 17, 1888; E. Hermite and C. F. Cooper, Pownall road, Dalston, Middlesex, England.

Electrolyzes chlorides between trough-shaped anodes of platinum, purified plumbago or glass, etc., faced with plumbago, and horizontal, revolving zinc cylinder cathodes, in each trough. Scrapers bear on the cathodes to remove deposit.

382,159. May 1, 1888; E. Hermite, Paris, France.

Electrolyzes a 5 per cent. solution of magnesium chloride and adds some magnesia. Anodes and cathodes, alternate vertical plates of platinum and zinc, respectively. A copper rod terminal is soldered to the end of each anode. The anodes are supported in wooden frames, molten sulphur being run in around the terminals. Hanks of yarn to be bleached are supported above the electrodes, on a vertically-reciprocating

frame. The current is occasionally reversed to detach any deposit from the zinc cathodes.

396,325. January 15, 1889; Arthur Brin, Brompton Crescent, Middlesex, England, and Leon Q. Brin, Paris, France.

Passes a mixture of chlorine 10 per cent., and oxygen 90 per cent., through an ozonizer and then into a pulp-beater engine. Produces gas mixture by forcing oxygen into a heated retort containing manganese peroxide and hydrochloric acid.

398,045. February 19, 1889; Eugene Hermite, Edward J. Paterson and Charles F. Cooper, London, England.

Electrolyzes magnesium chloride. Rectangular cell divided by a transverse, vertical partition having an opening containing alternate, vertical plate electrodes. Platinum anodes. Zinc cathodes, each embraced by a pair of scraper blades. All the scrapers are fixed in a vertically-reciprocating frame. A propeller, placed in an opening in the partition below that containing the electrodes, causes the electrolyte to circulate between the electrodes.

471,454. March 22, 1892; Albert E. Woolf, New York City.

Electrolyzes sea water. Cathode, parallel, perforated plates of carbon, between which is the platinum anode. Injects air into the space between cathode plates, by a perforated pipe coil.

522,839. July 10, 1894; Oskar Knoßler, Charlottenburg, Germany.

Bipolar electrodes, each consisting of a number of square carbon or platinum panes, set in a frame of iron, covered by hard rubber, or clay, glass, celluloid, or water-proofed wood. Electrodes clamped in series, the cell resembling a filter press. Cell compartments may be independent or connected in series.

541,147. June 18, 1895; Henry Blackman, New York City.

Electrolyzes sodium chloride and runs hypochlorite into pulp-beater engine, where it is heated by injected steam. Spent solution cooled, strengthened by fresh brine and returned to cell. May place cooling pipes in the cell itself. Anodes of platinum; cathodes of zinc.

553,465. January 21, 1896; Eugene Hermite, London, England.

Passes sea water, or a solution of sodium chloride with a little magnesium chloride, through a series of cells, each consisting of a vertical glass tube with its ends closed by plugs, through which pass the glass inlet and outlet pipes. Anodes, platinum; cathodes, zinc. Hypochlorite delivered into a receiving tank having a float which controls the supply of electrolyte and electricity.

558,240 and 558,241. Charles N. Waite, Rumford Falls, Maine, assignor to the Electro-Chemical Co., Rumford Falls, Maine.

Removes caustic solution, containing some sodium chloride, from cathode compartment of a diaphragm electrolytic cell, and uses in a wood-fibre digester. The soapy liquor from the digester, containing salt and the excess of caustic, is evaporated and the resulting black ash roasted and leached with water. The sodium carbonate first dissolves and may be separately recovered. The subsequent solution is treated with quick lime and returned to the cathode compartment of the cell. May causticize the entire leach solution, and return to the cell. In either case, add sufficient salt to maintain strength of solution.

559,454. May 5, 1896; Carl Kellner, Vienna, Austria-Hungary.

Runs caustic solution from electrolytic cell into an open vessel, where it is agitated to remove the hydrogen, and then down through an absorption tower. Injects the chlorine upward through bottom of tower. Uncombined chlorine forced into bleaching vessel by an ejector pipe, which sprays the bleaching liquid into the chlorine. Adds some hydrochloric acid to the brine electrolyte. The absorption tower may be filled with limestone to produce hypochloric acid.

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